State of Utah
SPENCER J. COX
Governor

DEIDRE HENDERSON
Lieutenant Governor

Department of
Environmental Quality

Kimberly D. Shelley
Interim Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

DAQP-011-21

January 29, 2021

Carl Daly
Acting Director, Air and Radiation Division
Environmental Protection Agency, Region 8
1595 Wynkoop St.
Denver, CO 80202-1129

Re: Initial Feedback on Portions of Utah's Retrospective 179B(b) Demonstration

Dear Mr. Daly:

The Utah Division of Air Quality (UDAQ) is formally requesting feedback on portions of a conceptual model for an International Transport Demonstration (179B(b)). UDAQ appreciates the willingness that Environmental Protection Agency (EPA) staff have shown to work closely with us on Utah's 179B(b) demonstration for the Northern Wasatch Front Ozone Nonattainment Area. EPA's feedback up to this point has been helpful. The reason for this request is to better understand EPA's stance on what constitutes adequate evidence of international transport and if the preliminary analysis below supports continued pursuit of a retrospective demonstration.

EPA's final guidance on preparing 179B demonstrations suggests that "An air agency also may choose to share an early engagement draft demonstration with its EPA Regional office for review and feedback prior to submitting a final demonstration to EPA." While the information below does not constitute a full draft demonstration, UDAQ is following EPA's guidance to coordinate with them early in the process and is requesting review and feedback on these two portions of a draft demonstration.

The two analyses below reflect EPA's recommendation that the conceptual model include "a summary of the meteorological and atmospheric conditions that lead to high concentrations at the monitor on days influenced by international anthropogenic emissions and days not influenced by international anthropogenic emissions." To determine the influence of international anthropogenic source emissions on local ozone concentrations along the Wasatch Front, UDAQ's Technical Analysis team conducted two different analyses:

1. Synoptic pattern analysis
2. Backward dispersion analysis using HYSPLIT modeling

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In both analyses, UDAQ scientists examined the 2017 summer period (June - August) with a focus on days leading up to Northern Wasatch Front exceedances of the 8-hour ozone National Ambient Air Quality Standard (NAAQS). It's worth noting that this summertime period coincides with UDAQ's recently proposed 8-hour Northern Wasatch Front SIP modeling episode.

The synoptic pattern analysis consisted of examining 2017 temperature, pressure, and vertical sounding data from the Salt Lake City International Airport (KSLC) along with ozone data collected from UDAQ's air monitoring sites in the Wasatch Front. The analysis revealed that the majority of ozone exceedance days shared meteorological characteristics that are not typically associated with the long-range transport of air pollution:

- High pressure (no downwelling of upper tropospheric ozone)
- No coincident frontal passages (no stratospheric intrusions or downwelling)
- Low surface winds (no non-local surface transport)
- Sunshine (no large convective systems adding lightning NO_x or upper level ozone to local conditions)

A second analysis using the NOAA HYSPLIT model was conducted in order to augment the conclusions from the first analysis. HYSPLIT consists of a series of programs that read meteorological data files in order to compute trajectories, particle dispersion, and air concentrations.

The purpose of this analysis was to determine transport patterns between upwind geographical regions and the Salt Lake Valley. HYSPLIT simulations were configured based on maximum daily 8-hour ozone measurements. For each exceedance and non-exceedance day, frequency plots were developed showing the fraction of particles in a given region. This fraction is an indication of where particles spent time before eventually reaching receptor sites in the Salt Lake Valley.

The HYSPLIT analysis did not show any significant difference in transport patterns between exceedance and non-exceedance days. While the fraction of particles over Canada increased during exceedance days compared to non-exceedance days, this Canadian fraction is much smaller than that over the continental United States (US). Considering human population as a proxy for global urban emissions, UDAQ staff could not identify significant emissions contributions from outside the US.

UDAQ staff finds the HYSPLIT analysis to be consistent with those of the synoptic pattern analysis. Results from these two independent analyses suggest there was not a strong impact from international emission sources on local ozone concentrations on exceedance days. Peak ozone measurements did not coincide with strong frontal passages, which would be expected with the long-range transport of international emissions. There was no significant difference in transport patterns between exceedance and non-exceedance days. Finally, there appeared to be a larger contribution of air to the Wasatch Front from the US compared to urban regions outside the US.

UDAQ appreciates the opportunity to work closely with EPA to resolve questions and concerns as we work on the technical pieces of Utah's 179B(b) demonstration. UDAQ has limited resources to

meet all of the current air quality regulatory requirements for Utah and would greatly appreciate a written response to help us determine how to best allocate available resources.

Additional details of the technical analyses are attached. If you have any questions please contact Chris Pennell (801-536-4098) or Becky Close (801-536-4013) of my staff.

Sincerely,

Bryce C. Bird
Director

BCB:BC:jf

Attachment

2017 Summer Ozone Wasatch Front

Synoptic Patterns & HYSPLIT Backward Dispersion Analysis

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
AIR QUALITY

Overview

- To determine the influence of international anthropogenic source emissions on local ozone concentrations along the Wasatch Front, two different analyses were conducted:
  - Synoptic Patterns Analysis
  - Backward Dispersion Analysis using HySPLIT

- Summer 2017, which corresponds to the selected modeling episode, was considered in the analysis, with focus on exceedance, non-exceedance days leading up to exceedances and other non-exceedance days.

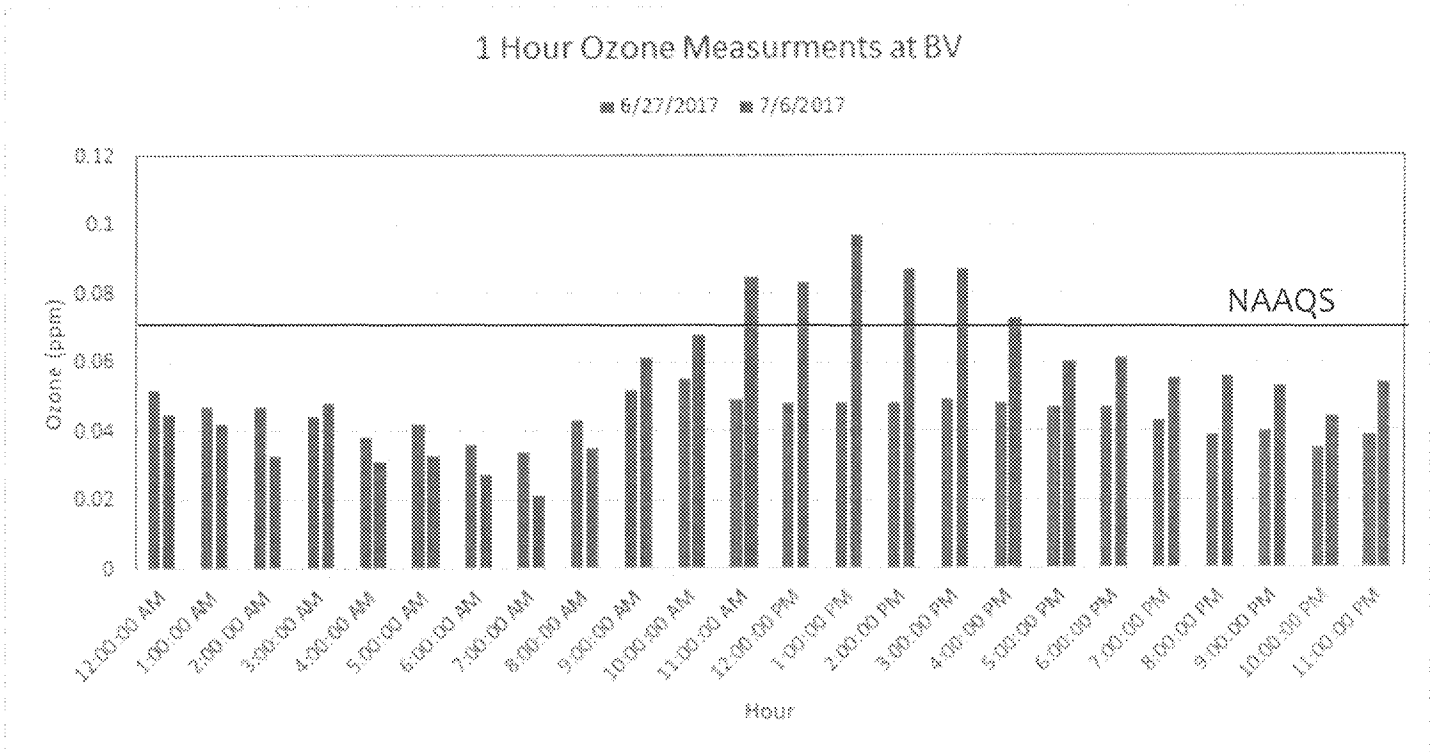
Summary of Exceedance Day Meteorology

The majority of ozone exceedance days share these synoptic characteristics:

- High pressure (no downwelling of upper tropospheric ozone)
- No coincident frontal passage (no stratospheric intrusions or downwelling)
- Low surface winds (no non-local surface transport)
- Sunshine (no large convective systems adding lightning NOx or upper level ozone to the local mix)

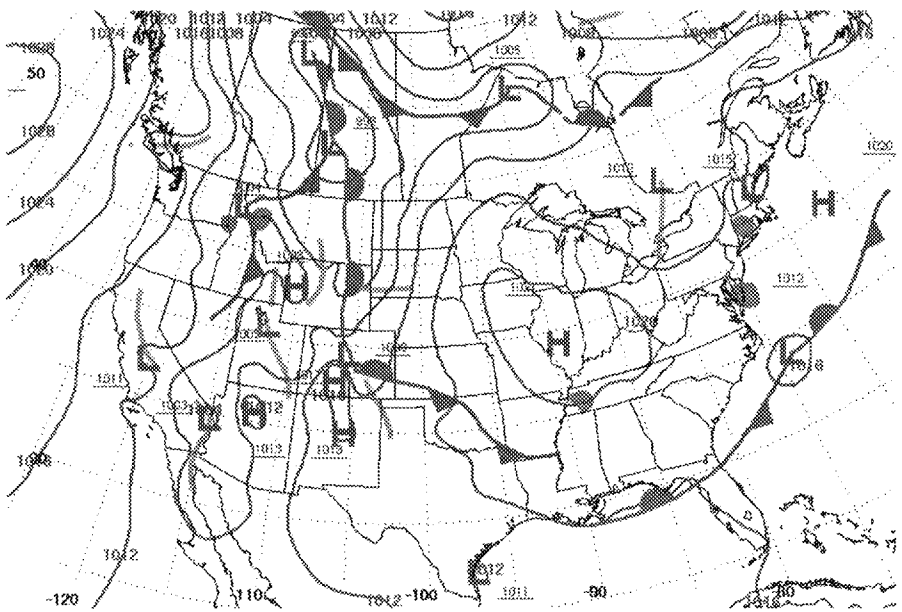
1 Hr. Ozone June 27th vs. July 6th

The one hour ozone measurements at the State of Utah's Bountiful monitor show the difference between the non exceedance day June 27, 2017, and the exceedance day July 6, 2017.

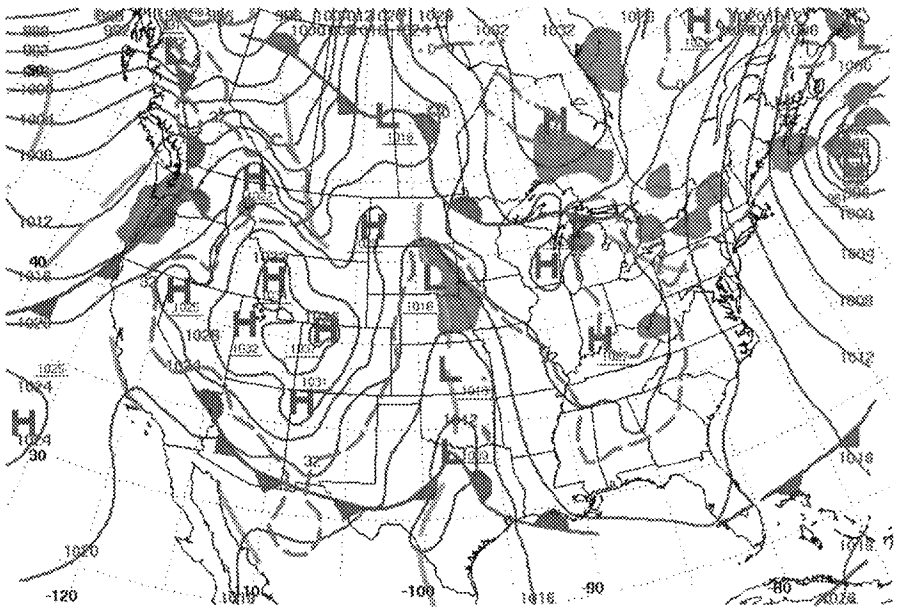


Surface Chart

A weak cold front moved through the monitoring area June 27th. This coincides with a decrease in measured ground level ozone.



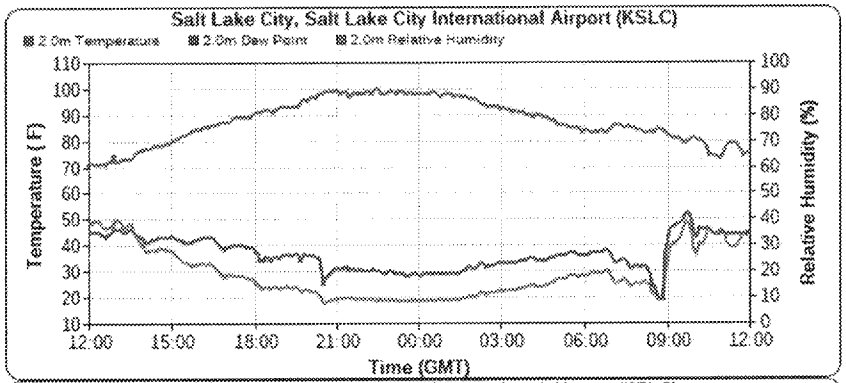
Surface Weather Map at 7:00 A.M. E.S.T.

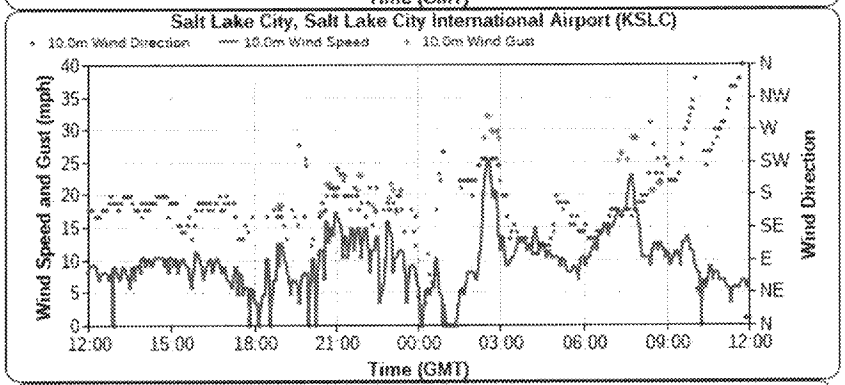


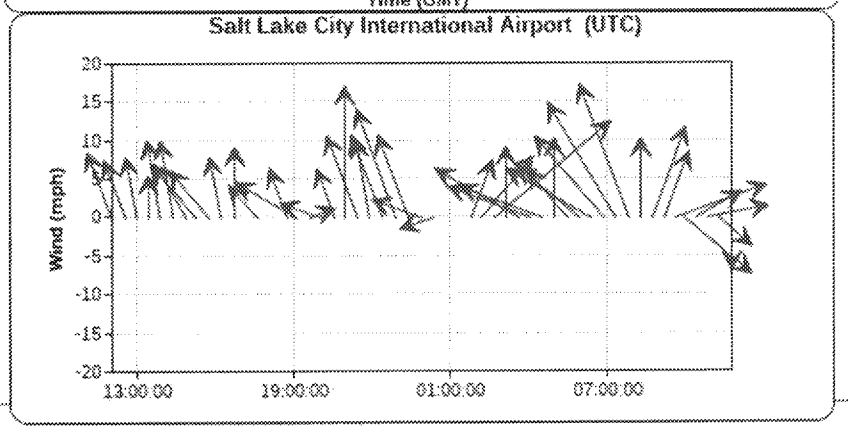
Surface Weather Map at 7:00 A.M. E.S.T.

Following few days after the passage of the front, a period of increasing stagnation moved into the area. With high pressure settling in across much of the inner mountain west July 6th.

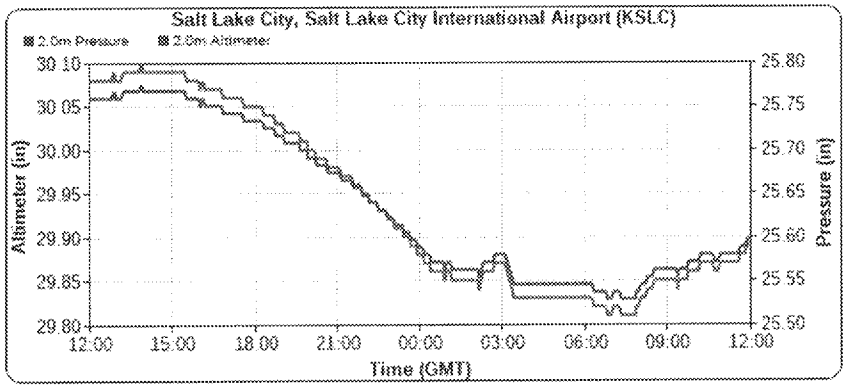
June 27 Charts



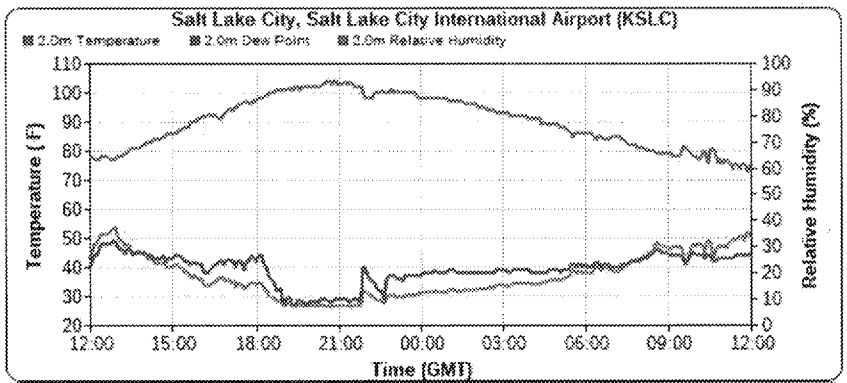


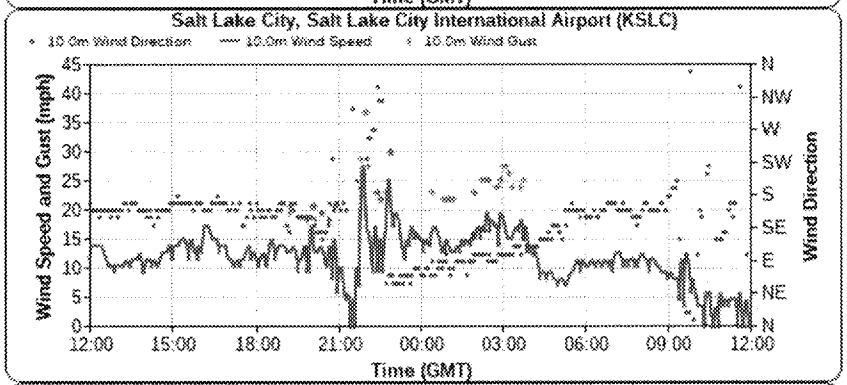


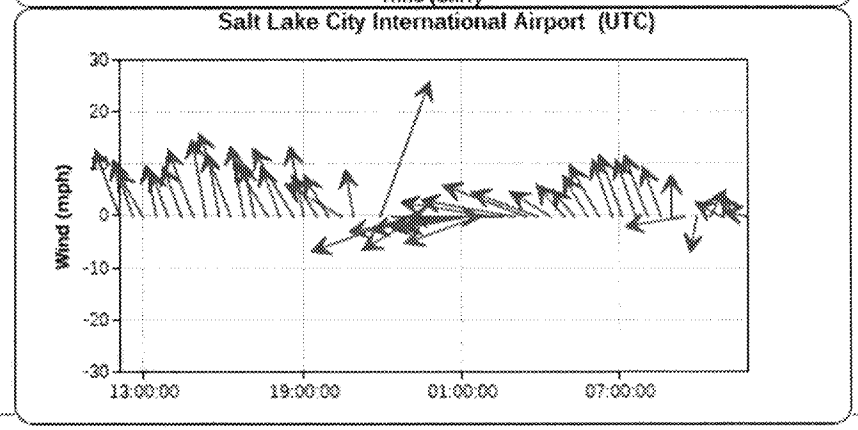
The ground based measurements indicate the passage of a cold front on June 27. This front was not associated with an increase in ozone measurements, rather it is associated with a decrease in ozone across much of the wasatch front ambient air monitor network.



July 6 Charts

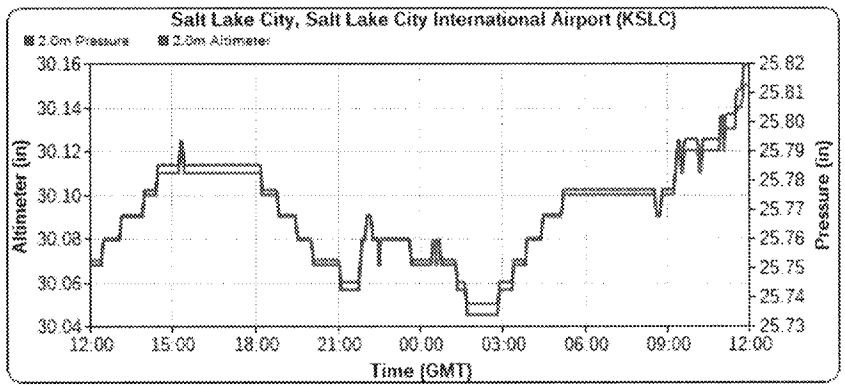






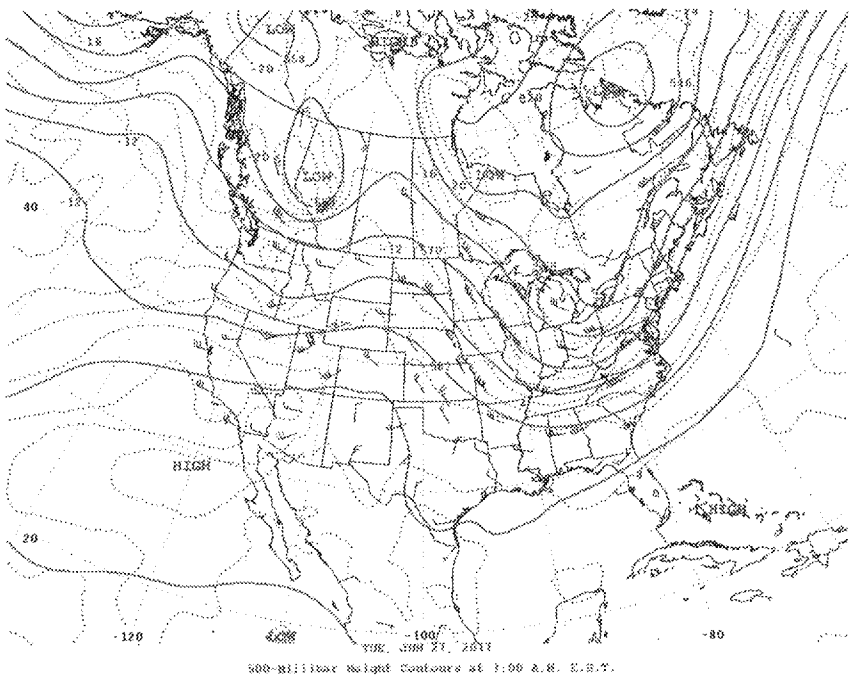
The ground based measurements show a slight increase in pressure on July 6th.

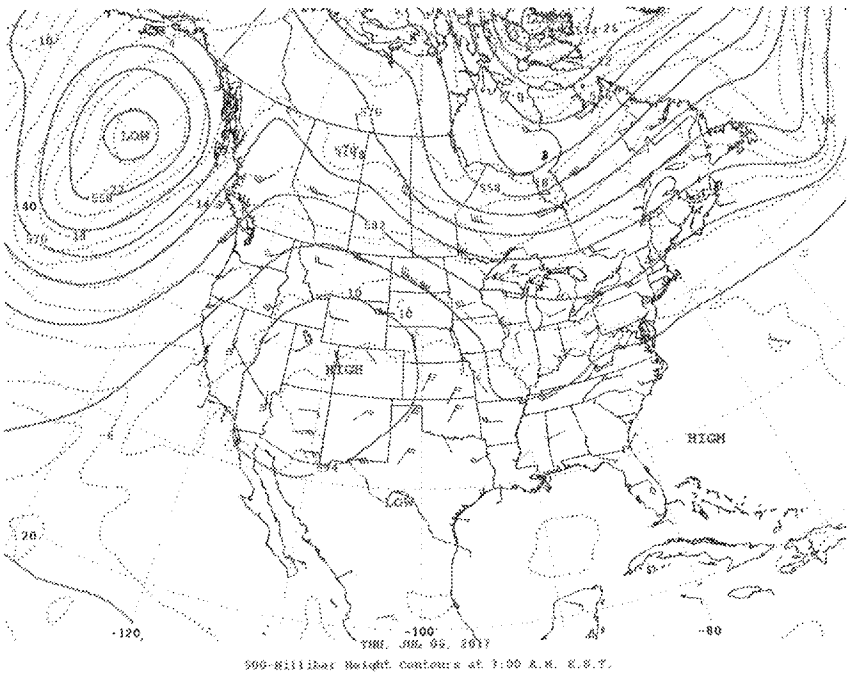
Afternoon clouds were not widespread enough to prevent an ozone exceedance.



500 mb Chart

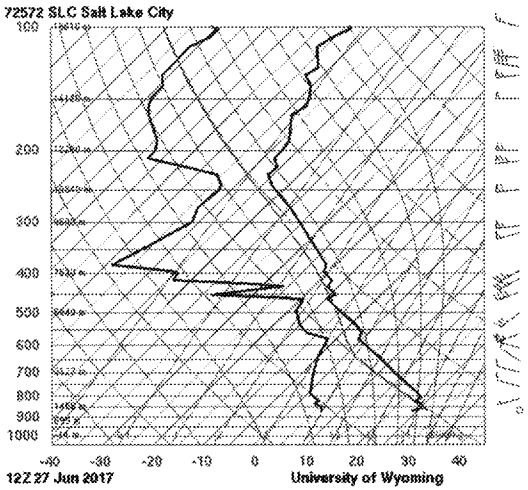
The upper level winds on June 27th show mostly zonal flow.

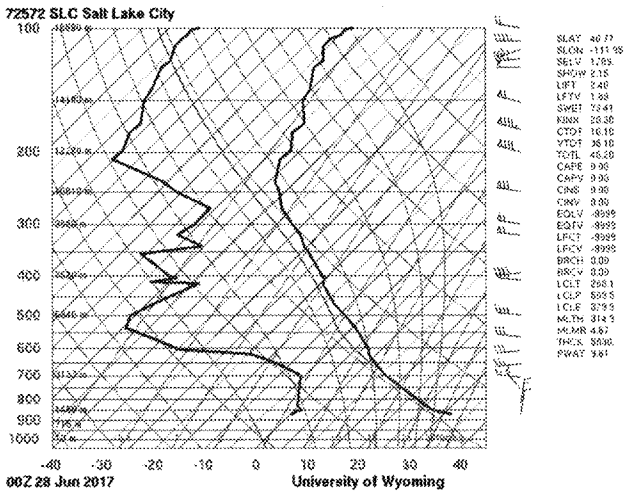




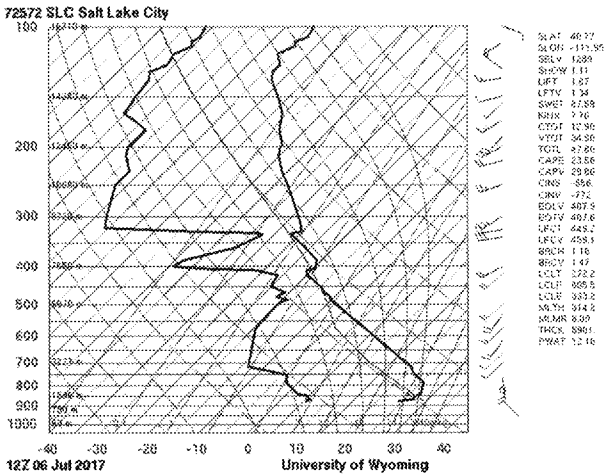
The upper level winds on July 6th show a ridge. This is associated with increased pressure

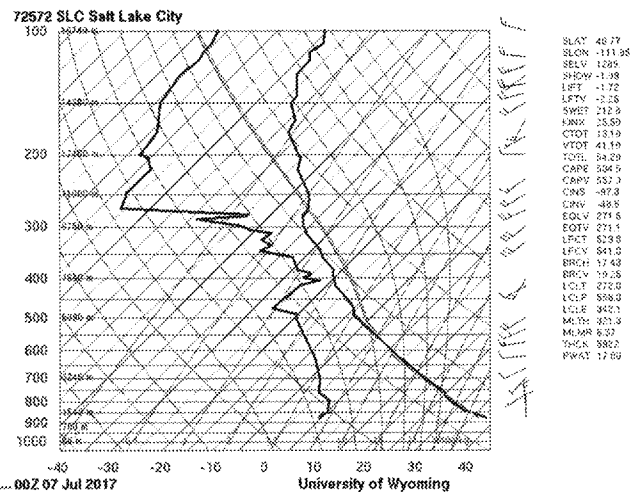
Vertical Temperature Soundings





Both days show weak morning inversion conditions, with these conditions disappearing with afternoon warming. The morning inversion was stronger the morning of July 6th.





NWS Forecast Discussion June 27th

288
FXUS65 KSLC 270944
AFDSLC

Area Forecast Discussion
National Weather Service Salt Lake City UT
344 AM MDT Tue Jun 27 2017

.SYNOPSIS...A weak upper trough will cross the region tonight and Tuesday. Additional weak troughs will clip northern Utah through Thursday.

&&

.SHORT TERM (THROUGH 12Z THURSDAY)...
Water Vapor Satellite shows a shortwave trough crossing Idaho. 400-200mb MDCARS wind observations place a 60-90kt subtropical westerly jet was nosing into Utah from California. GOES/SLC 002 RAOB/HRRR indicate that precipitable water values vary from 0.10"-0.20" central and southern mountains to 0.40"-0.60" northern valleys.

Passage of a cold front will take the edge off of temperatures across the north and central areas, with the boundary stalling near Interstate 70 late day. Left exit of aforementioned jet will continue to support high-based showers and thunderstorms into the morning hours. Despite developing strong instability this afternoon, the passage of this feature should limit convective chances. For valleys played as dry thunderstorms with gusty winds.

Westerly flow will mix down from aloft as the day progresses today and tomorrow, bringing a dry breeze to the region.

Northern stream wave currently over British Columbia should near northern Utah tomorrow, touching off isolated to scattered high-based shower and thunderstorms across the north. Given the cooling aloft and jet dynamics from the associated jet, elected not to use the dry thunderstorm wording for the northern valleys.

.LONG TERM (AFTER 12Z THURSDAY)...
The shortwave trough continues to slide southeast across the area through the day Thursday. With continued cold advection northwest flow, Thursday will likely be the coolest day of the week in many locations. The airmass behind the cold front looks fairly dry, but cannot currently rule out isolated mountain convection Thursday and Friday, primarily in the Uintas.

A relatively flat ridge looks to build over the west coast Thursday night, then shift over Utah on Friday and early Saturday, bringing a warming trend for those two days. Southwesterly flow increases a bit Saturday afternoon, as a weak trough slides into the Great Basin from the west. Models are still struggling a bit with this wave, including whether to cut it off over Nevada or push it across northern Utah as an open wave. For now, have kept some slight chance POPs in the higher terrain of Utah and across the far northwest on Saturday afternoon, to account for the possibility of increased instability with/ahead of the shortwave.

Despite different fates for this disturbance, global models re-converge on Sunday and Monday, building a ridge over the forecast area heading into early next week. Have maintained above normal temperatures and mostly dry conditions for days 5-7.

&&

.AVIATION...
West winds at the SLC terminal as of 0930Z are expected to switch back to the south or become light and variable around 11-13Z. Northwesterlies will eventually pick up a bit again through the afternoon hours. VFR conditions should prevail under mostly clear skies.

&&

.FIRE WEATHER...
ERC values have risen to between the 80th and 96th percentile across southern and central Utah. Far northeast Utah remains below 50th percentile, but the remainder of northern Utah is climbing above the 50th percentile.

Multiple concerns regarding fire weather. The Haines index will be a 6 today and tomorrow across central and southern Utah. Haines index will increase back to a 6 across the entire region next weekend.

Some of the driest RH values the region sees will continue to occur today and tomorrow while it remains warm despite the passage of a shallow cold front this morning. West southwest winds will respond by increasing. A Red Flag Warning is in place for much of the state of Utah today and tomorrow. Isolated high-based showers and thunderstorms primarily across the north and east early this morning may exaggerate the hazard bringing potential for lightning and gusty/erratic dry microburts. Luckily this threat should end this morning.

Another round of isolated to scattered high-based showers and thunderstorms primarily across the north re-develop tomorrow afternoon and evening, again bringing the hazard of lightning
...truncated 32 lines...

NWS Forecast Discussion July 6th

644
FXUS65 KSLC 061034
AFDSLC

Area Forecast Discussion
National Weather Service Salt Lake City UT
434 AM MDT Thu Jul 6 2017

.SYNOPSIS...Strong high pressure aloft will remain locked in
across the western states through the upcoming weekend.

&&

.SHORT TERM (Until 06z Monday)...The strong upper ridge locked in
across the western CONUS will remain the dominant feature
throughout the short term forecast period.

The center of ridge currently near the Utah/Colorado border is
progged by the GFS/ECMWF to shift slightly west and center over
Utah by Friday. The bulk of the available mid-level moisture will
remain on the periphery of the high center, which means limited
convection for the forecast area the next couple of days. Any
convection that does form over Utah will be high-based with little
or no precip and the potential for strong microburst winds.

Increasingly strong westerlies across the Pacific Northwest and
northern Rockies late in the weekend will serve to weaken the
ridge over the Great Basin. This weakening will allow a little
more moisture to work into northern/western Utah late Sunday, and
bring slightly cooler temps to northern Utah due to increased
cloud cover and slightly cooler near 700 mb temps.

.LONG TERM (After 06Z Monday)...The persistent upper ridge will be
in place across the CWA through Monday before shifting eastward for
the remainder of the long term forecast period. Mid-level moisture
will remain in place Monday keeping convective coverage widely
scattered or lower, with the main area impacted across the southern
two thirds of the CWA.

As the ridge shifts eastward Tuesday, expect moisture to deepen.
Model trends may indicate coverage of convection may be higher than
currently forecast. If model runs continue to show deeper moisture
Tuesday into Wednesday, pops may need to be increased with
subsequent packages. By Thursday, drier air begins to advect into
the area from west to east, keeping pops restricted to the Wasatch
spine and east.

&&

&&

.AVIATION...Southeasterly winds at the SLC terminal are
shift to the northwest between 20-22Z. Isolated high bas
convection is expected across northern Utah this afternc
evening. This may bring the threat of strong, gusty and
winds to the terminal between 21-01Z.

&&

.FIRE WEATHER...The strong upper ridge centered over the
Basin will remain the dominant feature across Utah throu
upcoming weekend. Very hot temperature with low humiditi
continue, with generally fair to poor RH recoveries the
couple of nights.

Sufficient mid-level moisture and strong surface heating
to high-based convection during the afternoon and early
hours today and Friday. Looking at little no chance at w
rains, with a few dry thunderstorms possible. Have addec
weather zone 498, the Grand Staircase, to the existing F
Warning in the morning forecast package.

A modest increase in moisture this weekend will lead to
increase in areal coverage of showers/storms statewide.
of wetting rains will improve slightly, and then mainly
the higher terrain.

&&

.SLC WATCHES/WARNINGS/ADVISORIES...
UT...Excessive Heat Warning from noon today to 10 PM MDT
     UTZ019-021.

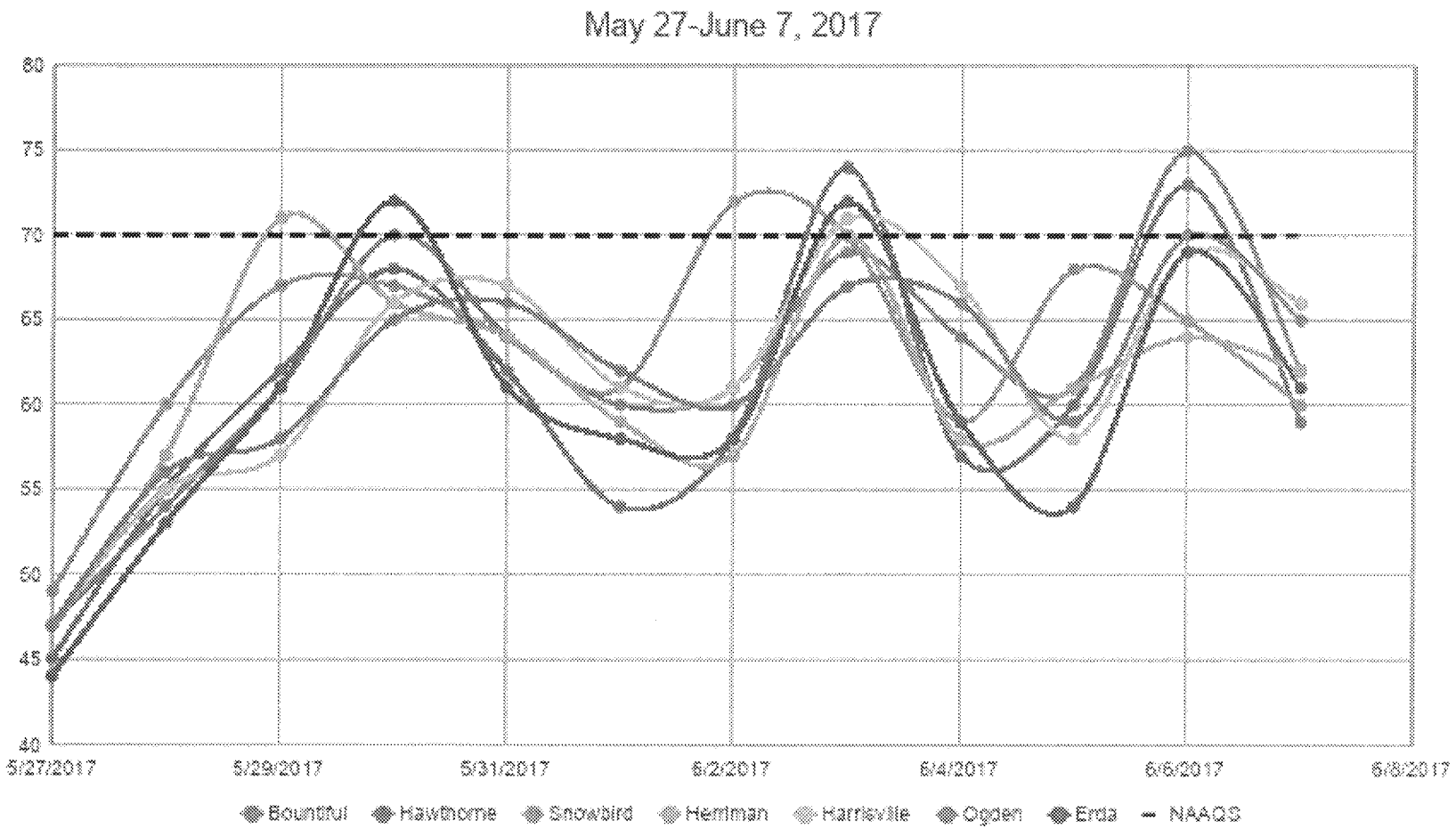
     Red Flag Warning from noon today to 10 PM MDT Frida
     479-481>484-488-492-493-496-498.

     Heat Advisory until 10 PM MDT this evening for UTZC

WY...None.
&&

$$

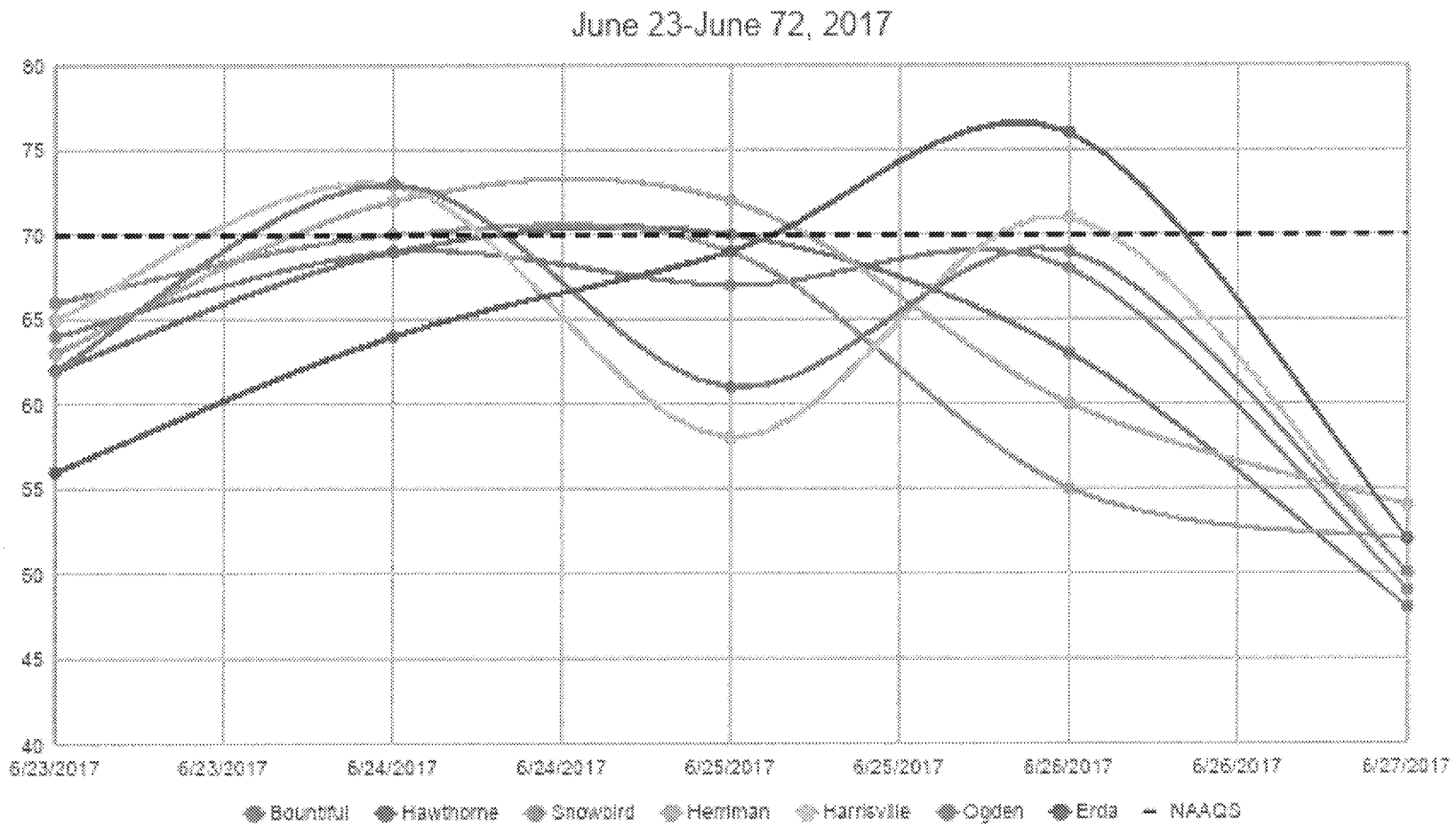
May 27 - June 07: MDA8 O3 (ppb)



May 27- June 07

- High pressure aloft caused a period of stagnation. This with sunny conditions and low ground level winds contributed to the increased Ozone.
- A weak trough moved through the area June 1st bringing stronger winds and reduced ozone measurements, before stagnation conditions returned and increased ozone.
- Strong south winds prior to a cold front moved through northern Utah June 5th reduced ozone measurements, followed by a stagnate June 6th.
- Peak ozone measurements do not coincide with frontal passage, which would be expected with long range transport of international emissions.

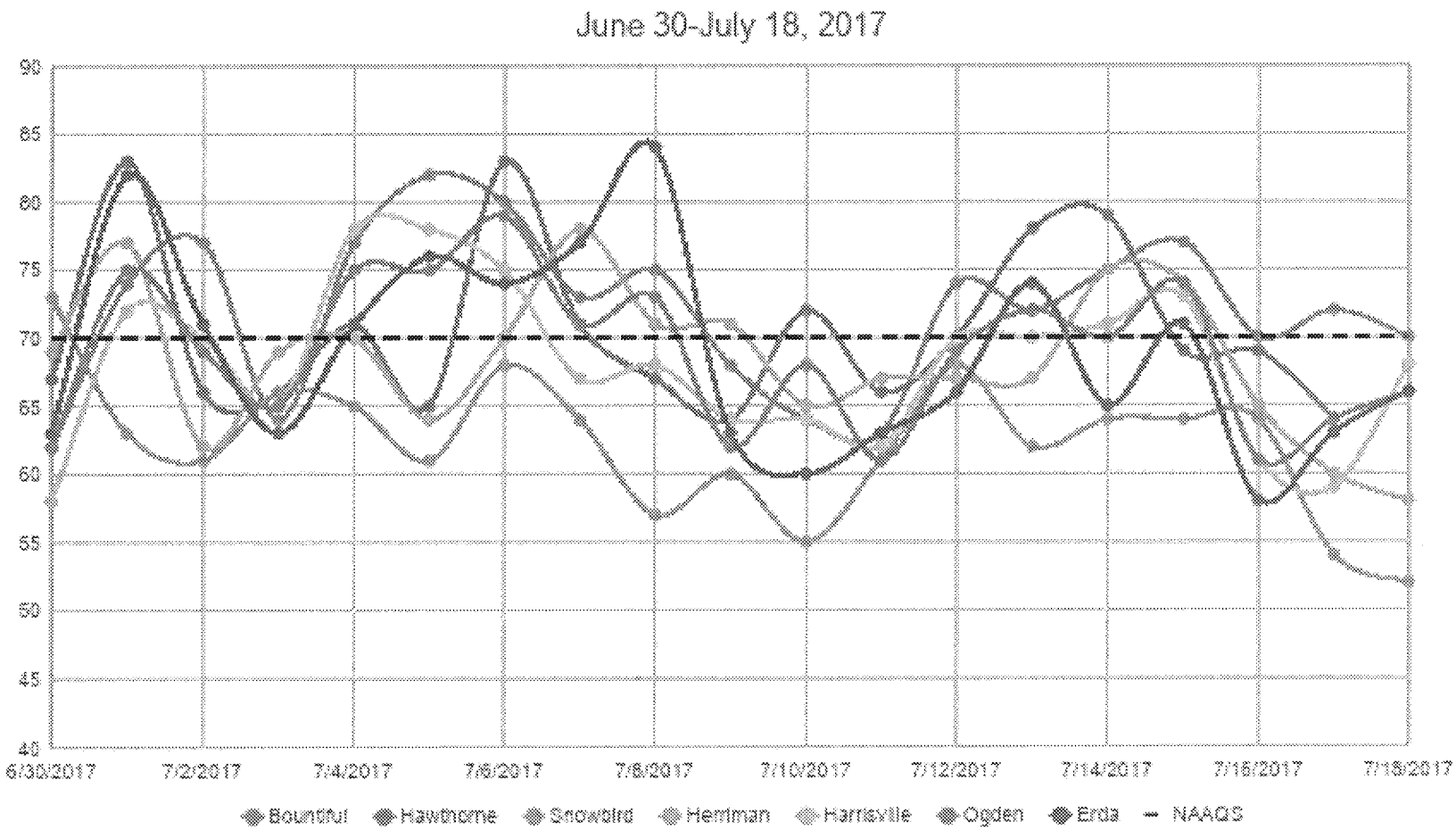
June 24 – June 26: MDA8 O3 (ppb)



June 24 – June 26

- Strong high pressure aloft returned to the area at the beginning of this event.
- Dry and sunny with high pressure ended Tuesday June 27th with increased moisture and lower temperatures.
- Peak ozone measurements do no coincide with frontal passage, which would be expected with long range transport of international emissions.

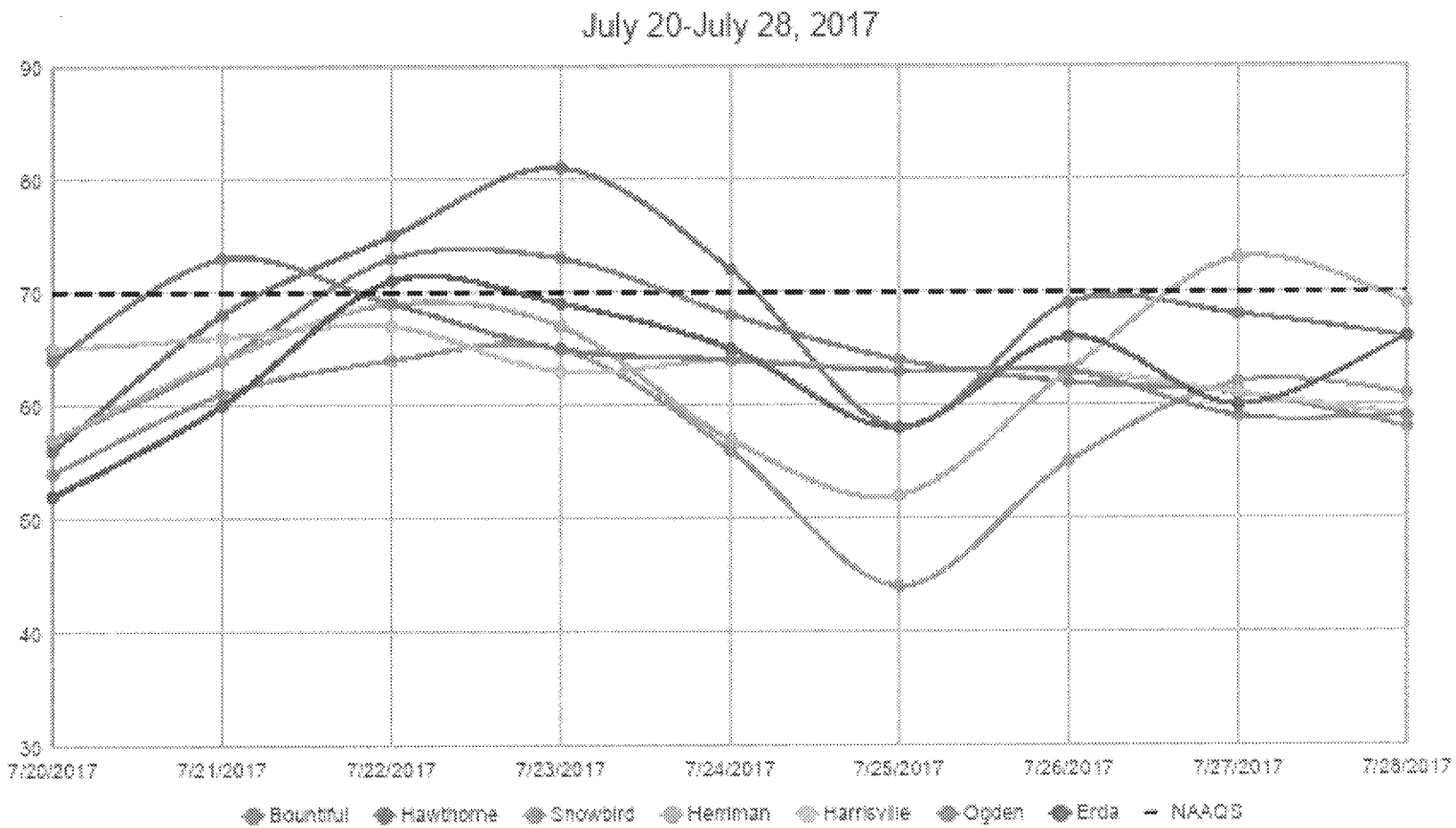
June 30 – July 17: MDA8 O3 (ppb)



June 30 – July 17

- High pressure aloft covered much of the western desert region. Variability in measurements between days and across locations mainly due to local cloud cover.
- The high-pressure weakened slightly July 10th-12th, then quickly re-strengthen. Cloud cover and storms greatly impacted where elevated ozone was observed.
- A weak and shallow cold front moved through northern Utah July 16th bringing spotty storms and increased surface winds in the 10-20 mph range with gusts in the mid. 20's.
- Peak ozone measurements do no coincide with frontal passage, which would be expected with long range transport of international emissions.

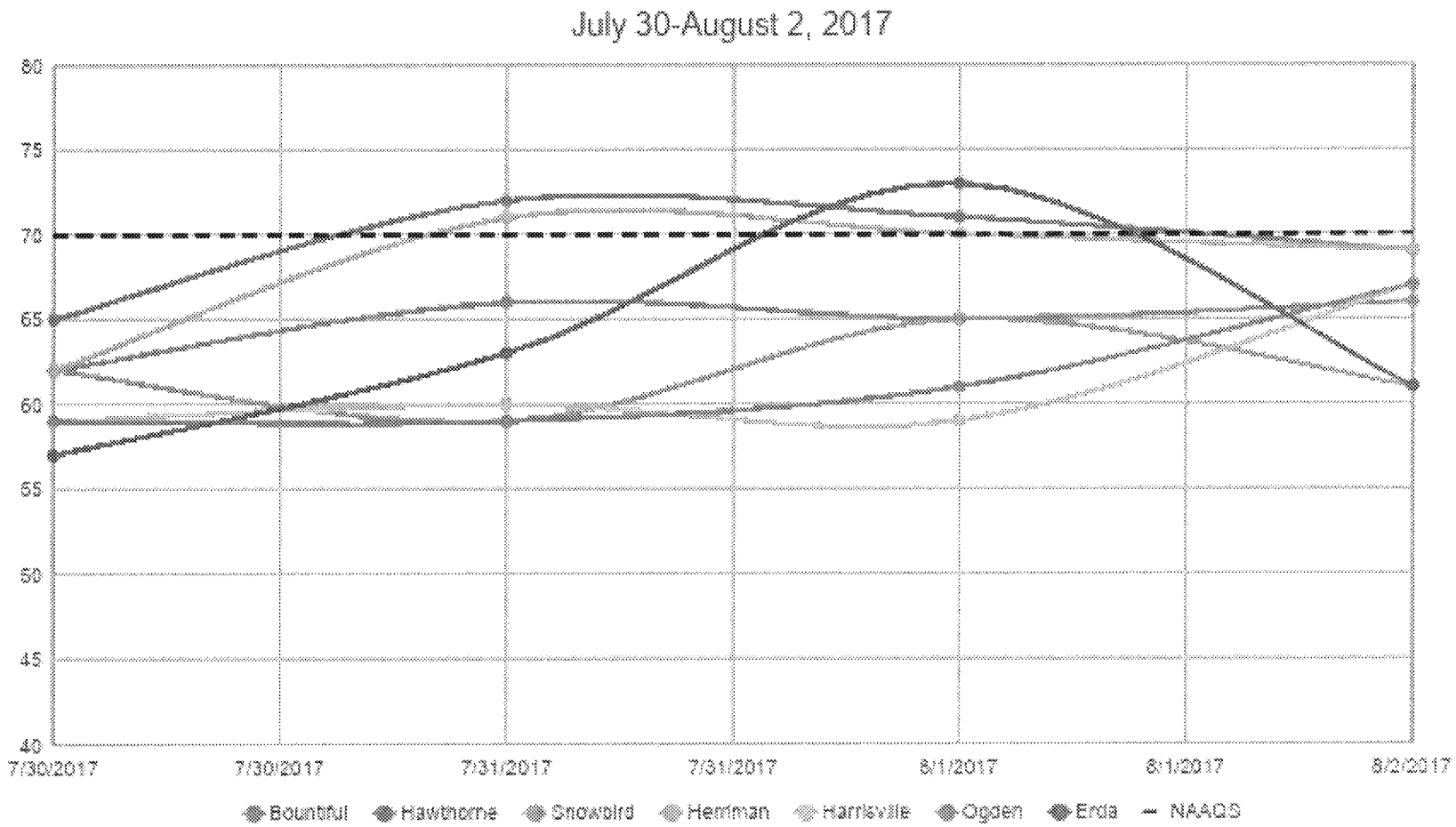
July 20 – July 28: MDA8 O3 (ppb)



July 20 – July 28

- A mid-level ridge brought dry conditions mostly clear skies over the weekend, then moving east after the beginning on the week.
- Moisture started to move in July 24th creating isolated clouds and thunderstorms creating spotty ozone formation
- Peak ozone measurements do no coincide with frontal passage, which would be expected with long range transport of international emissions.

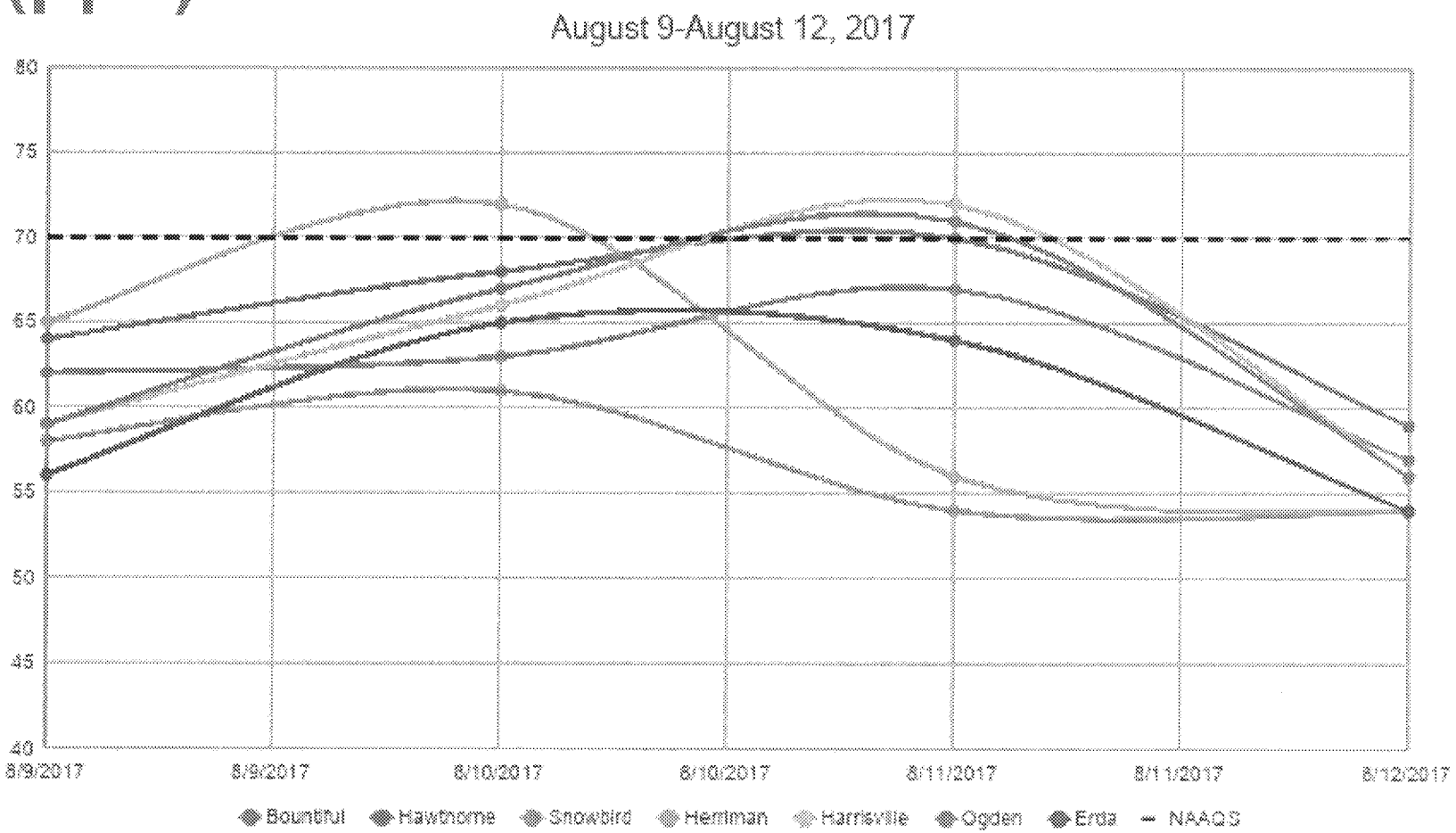
July 30 – August 02: MDA8 O3 (ppb)



July 30 – August 02

- Hot, dry, upper level high pressure, and clear skies, combined for the perfect conditions for ozone formation.
- A few scattered clouds August 1st afternoon impacted ozone formation.
- Increased winds August 2nd reduced ozone measurements.
- Peak ozone measurements do no coincide with frontal passage, which would be expected with long range transport of international emissions.

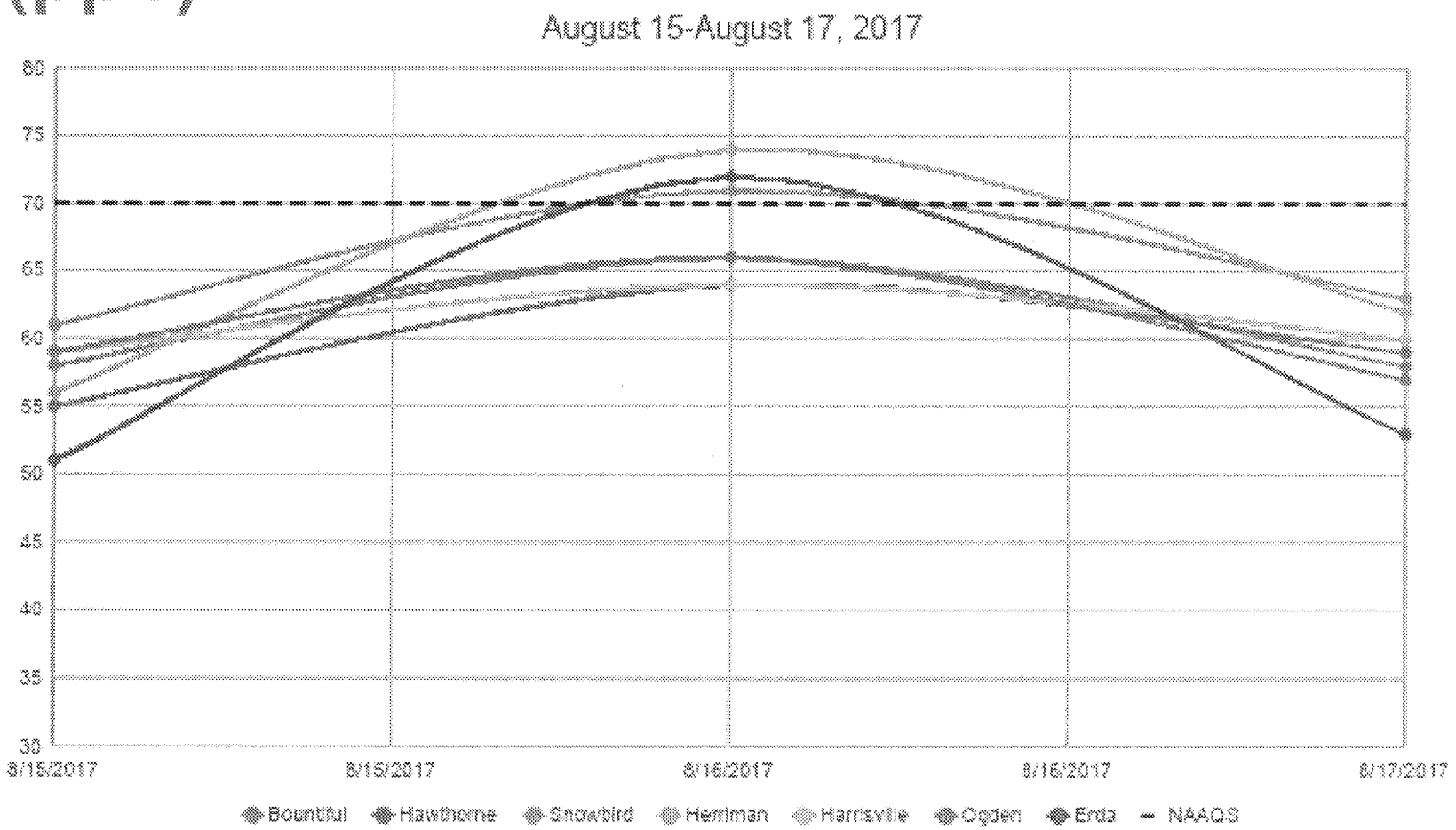
August 09 – August 12: MDA8 O3 (ppb)



August 09 – August 12

- A slight drying trend for two days allowed for increased solar radiation, and thus increased ozone in populated locations.
- Peak ozone measurements do no coincide with frontal passage, which would be expected with long range transport of international emissions.

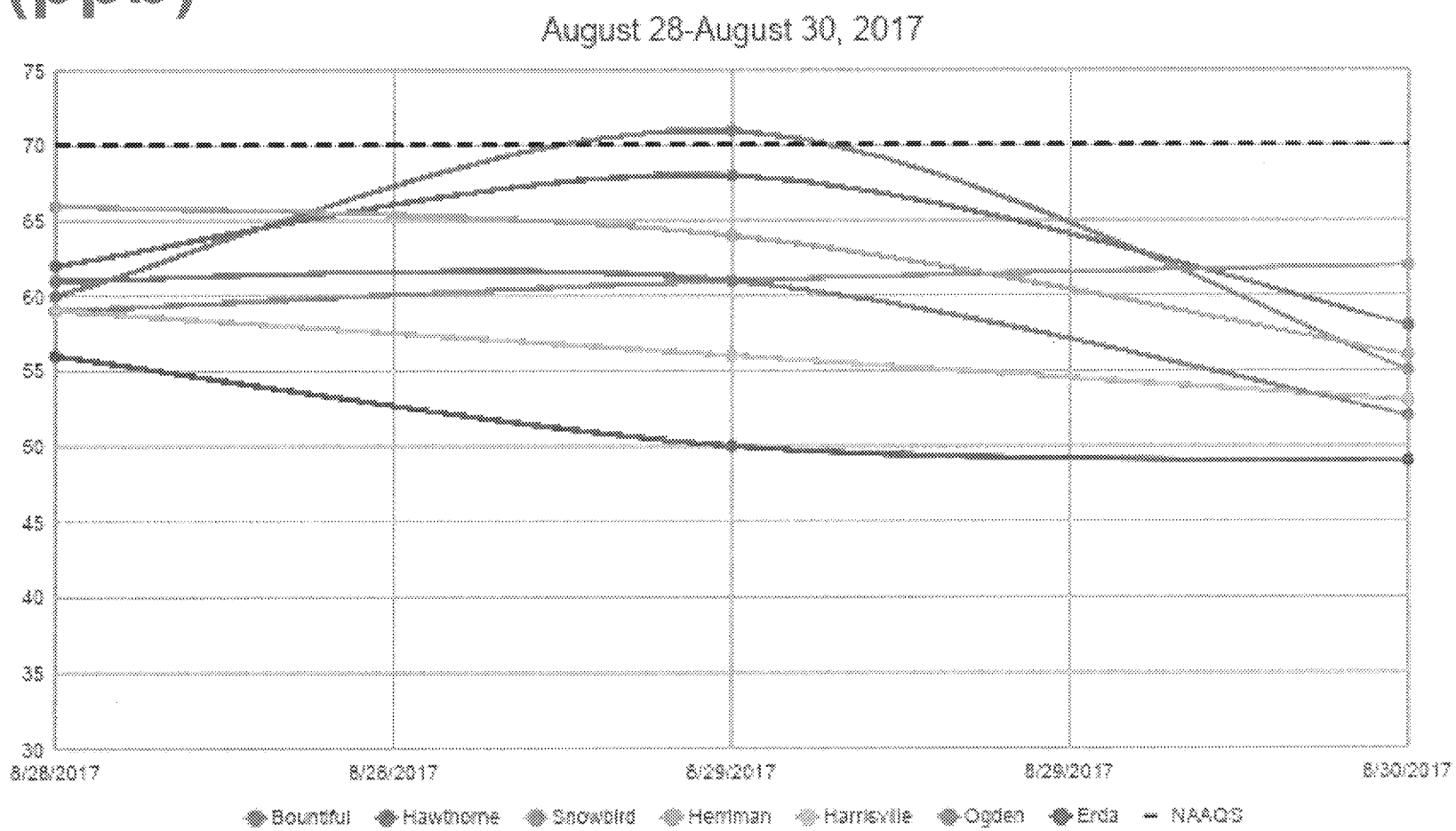
August 15 – August 17: MDA8 O3 (ppb)



August 15 – August 17

- Smoke/Haze was observed. Clear skis for most of the day, followed by evening clouds associated with a weak feature.
- Peak ozone measurements do no coincide with frontal passage, which would be expected with long range transport of international emissions.

August 28 – August 30: MDA8 O3 (ppb)



August 28 – August 30

- Potential smoke impact on Ozone.
- High pressure aloft continued, allowing to warm dry conditions. Afternoon and evening clouds
- Peak ozone measurements do no coincide with frontal passage, which would be expected with long range transport of international emissions.

HySPLIT Backward Dispersion

- Simulations configured based on MDA8 O3 measurements
- Assumed vertical line source with particles distributed uniformly between 100 and 1000 m over monitor
- 80,000 particles released over 8 hours with 10,000 particles released per hour

CAVEATS: not accounting for chemical transformation, physical loss processes and emission sources.

For each exceedance, non-exceedance day, frequency plots showing the fraction of particles in a given region were developed.

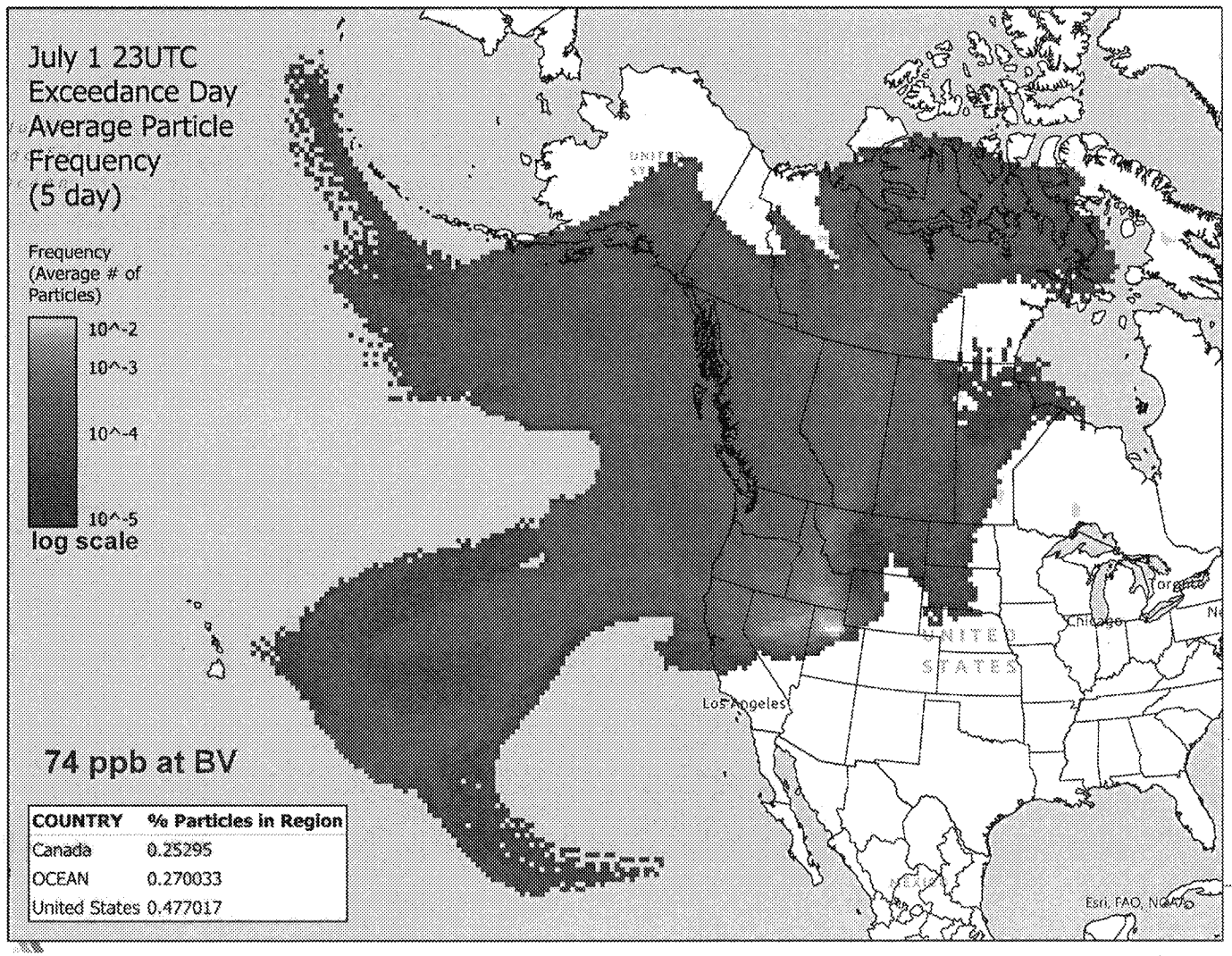
Backtrajectories represent the predominant meteorological pathway influencing Bountiful site, where particles over a given region are assumed to interact with source emissions within that region.

Only July 2017 plots are shown. Almost all exceedances occurred during this month.

Configuration	
Starting Location	Bountiful
Total run time	120 hours (5 days) backwards
Emission Rate (1/hr)	10,000
Hours of Release	8
Release Start Time	Last hour of 8-hr period over which MDA8 O3 occurs

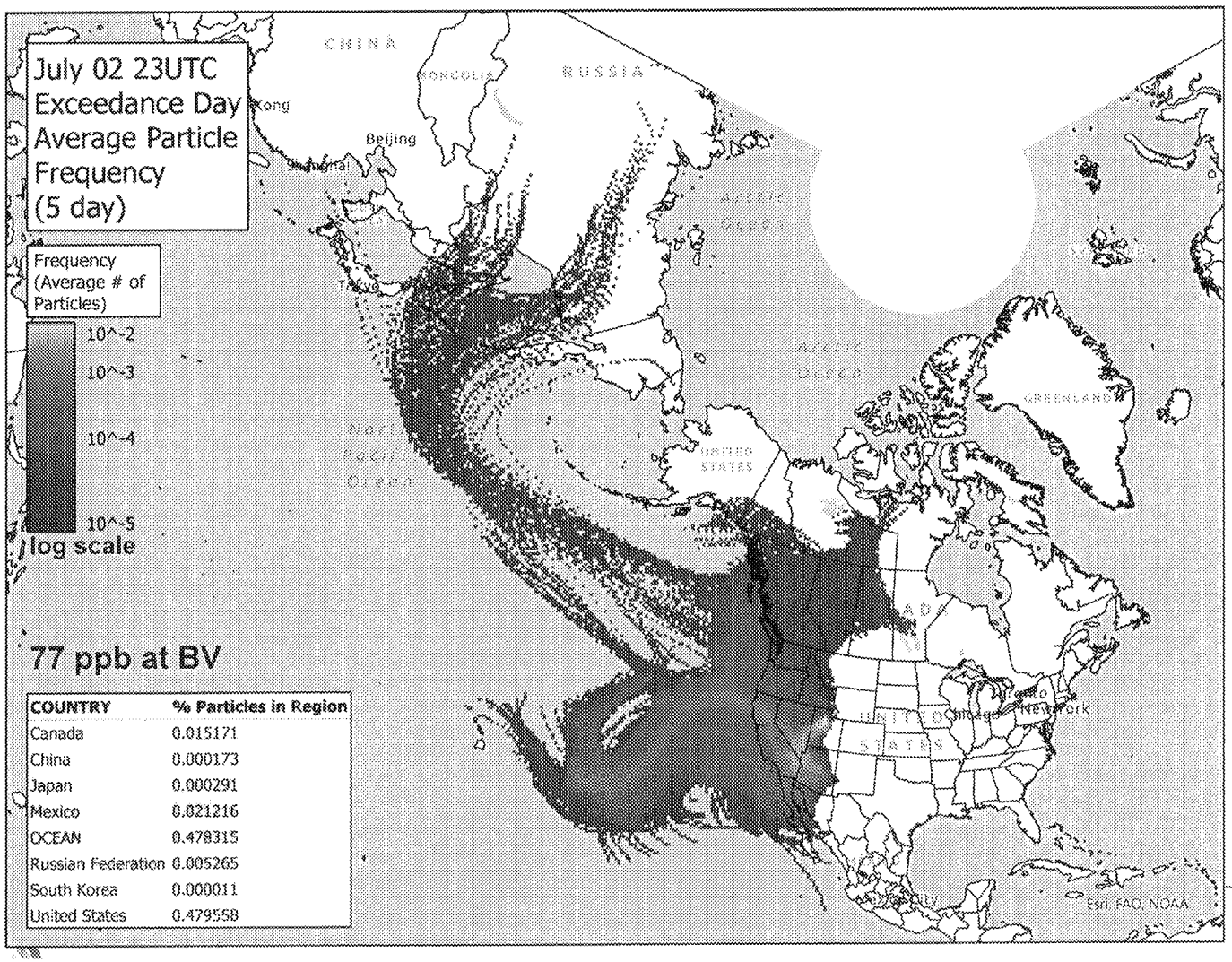
Exceedance

July 1 Average Particle Frequency



Exceedance

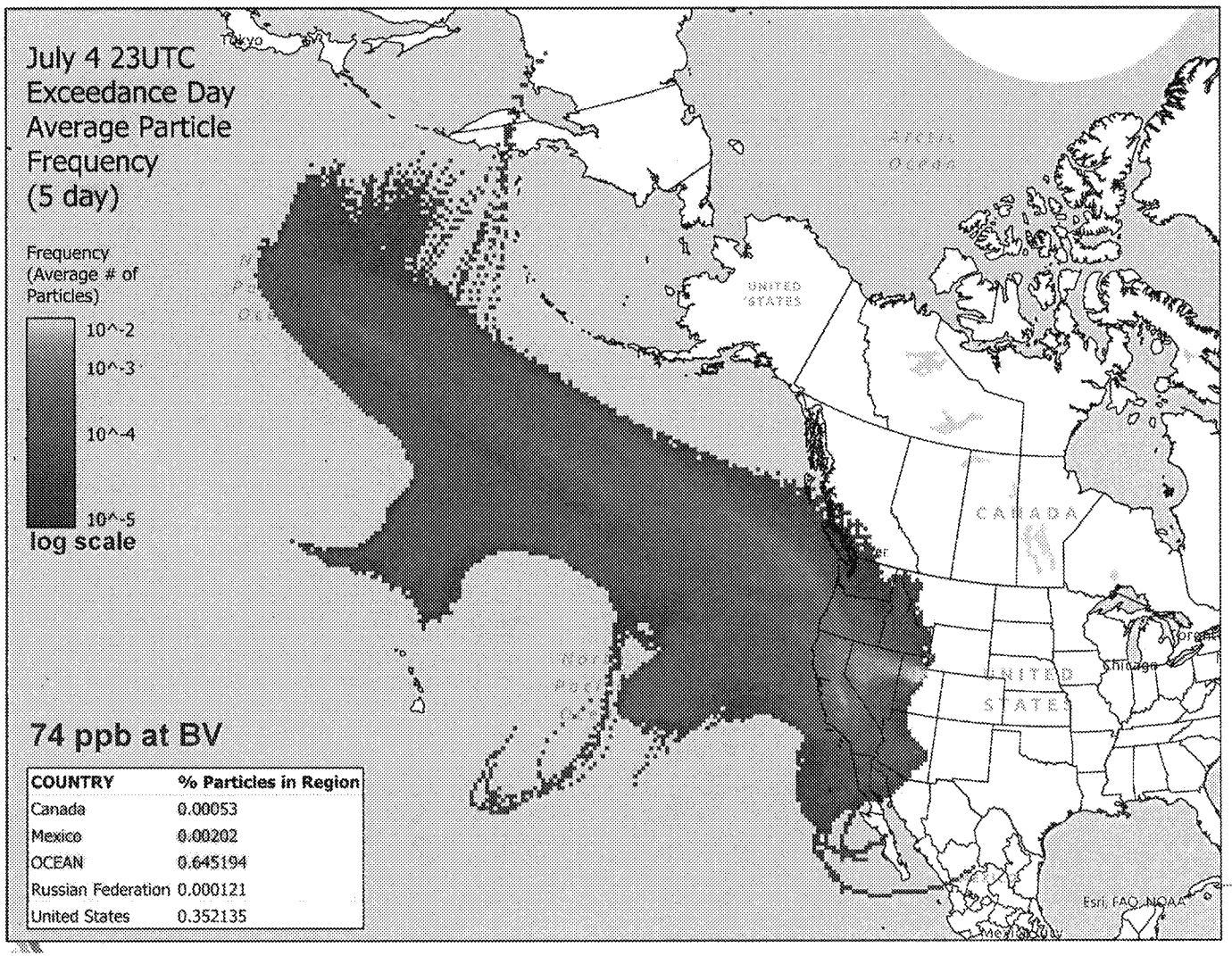
July 2 Average Particle Frequency



COUNTRY	% Particles in Region
Canada	0.015171
China	0.000173
Japan	0.000291
Mexico	0.021216
OCEAN	0.478315
Russian Federation	0.005265
South Korea	0.000011
United States	0.479558

Exceedance

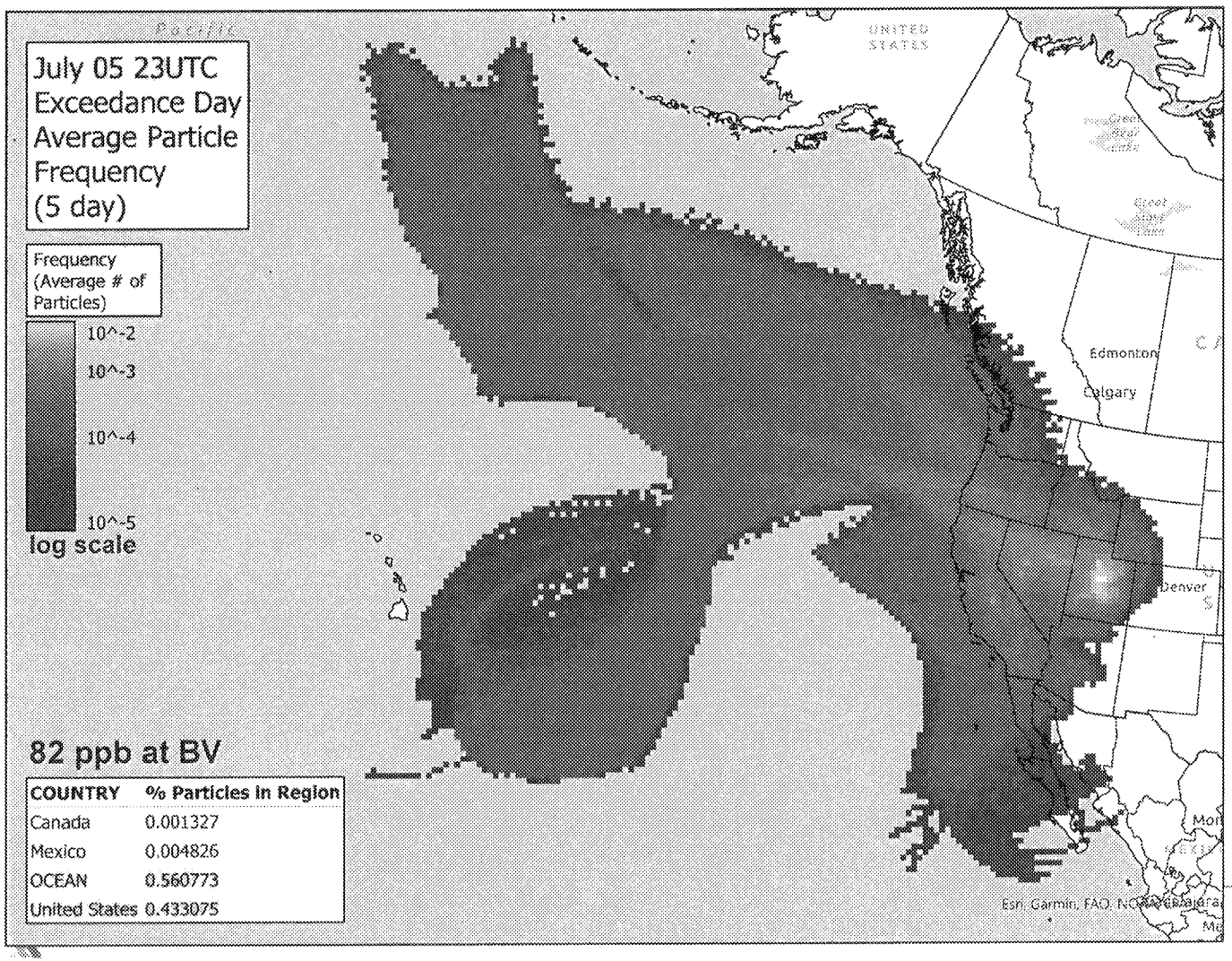
July 4 Average Particle Frequency



Division of Air Quality

Exceedance

July 5 Average Particle Frequency

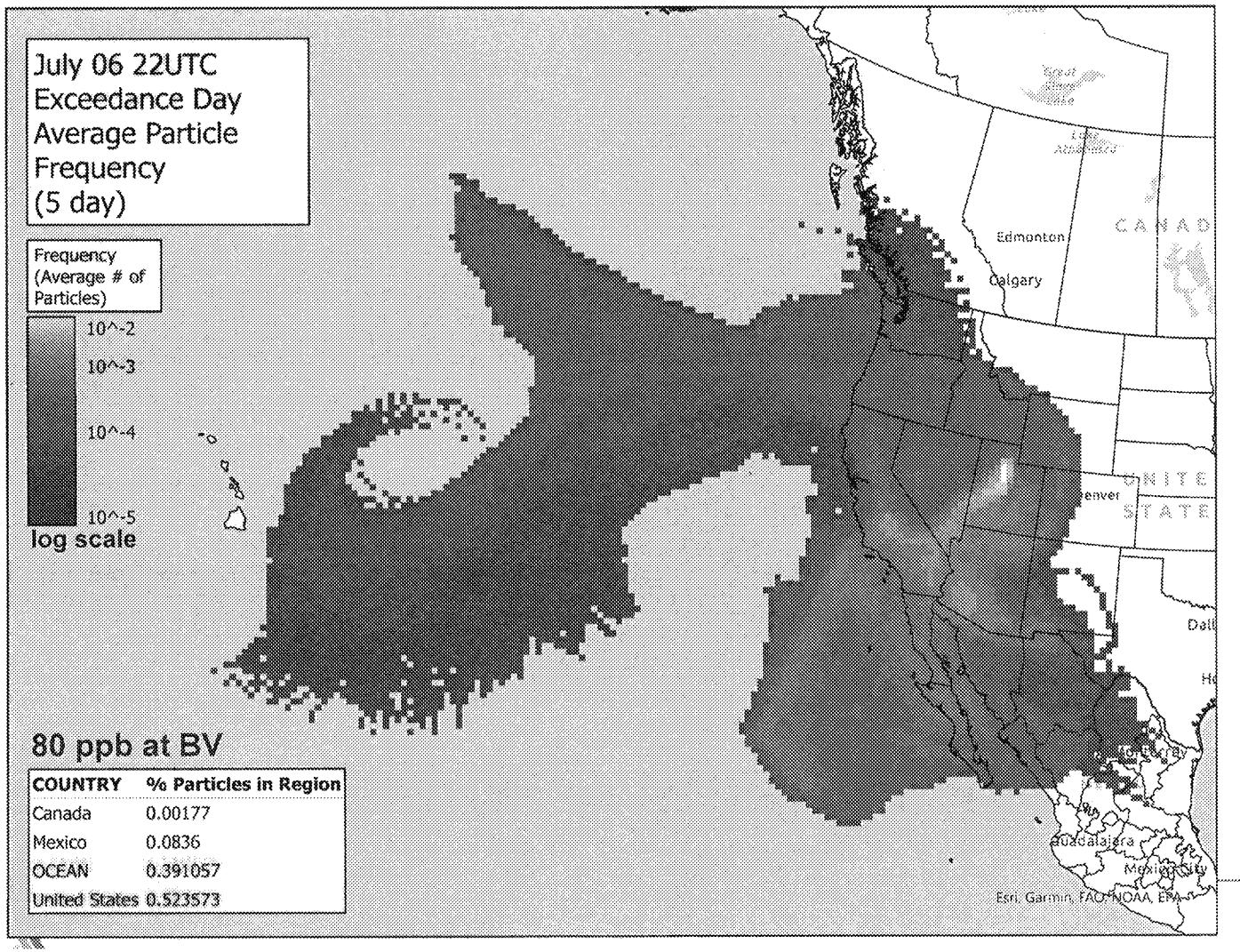


82 ppb at BV

COUNTRY	% Particles in Region
Canada	0.001327
Mexico	0.004826
OCEAN	0.560773
United States	0.433075

Exceedance

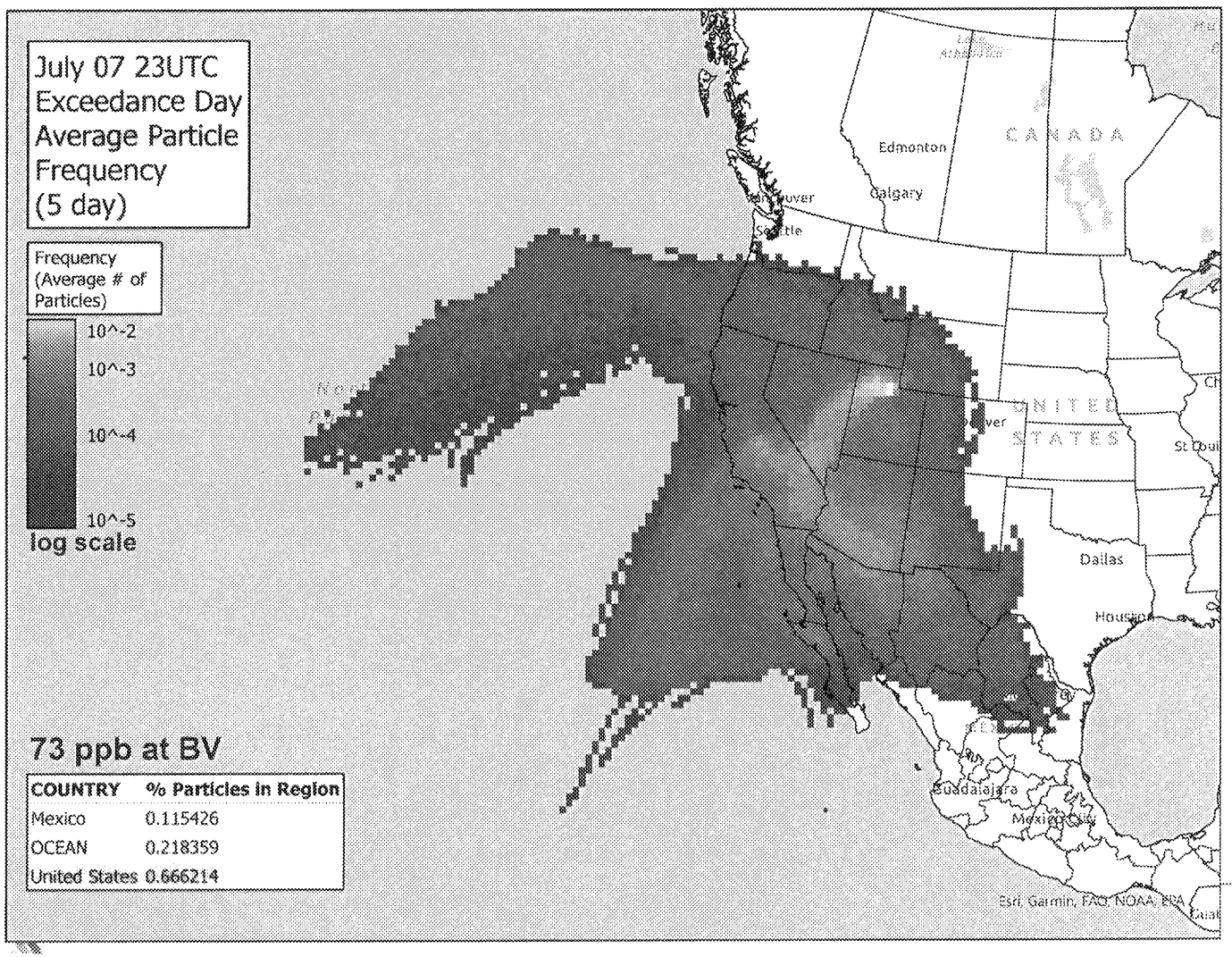
July 6 Average Particle Frequency



Division of Air Quality

Exceedance

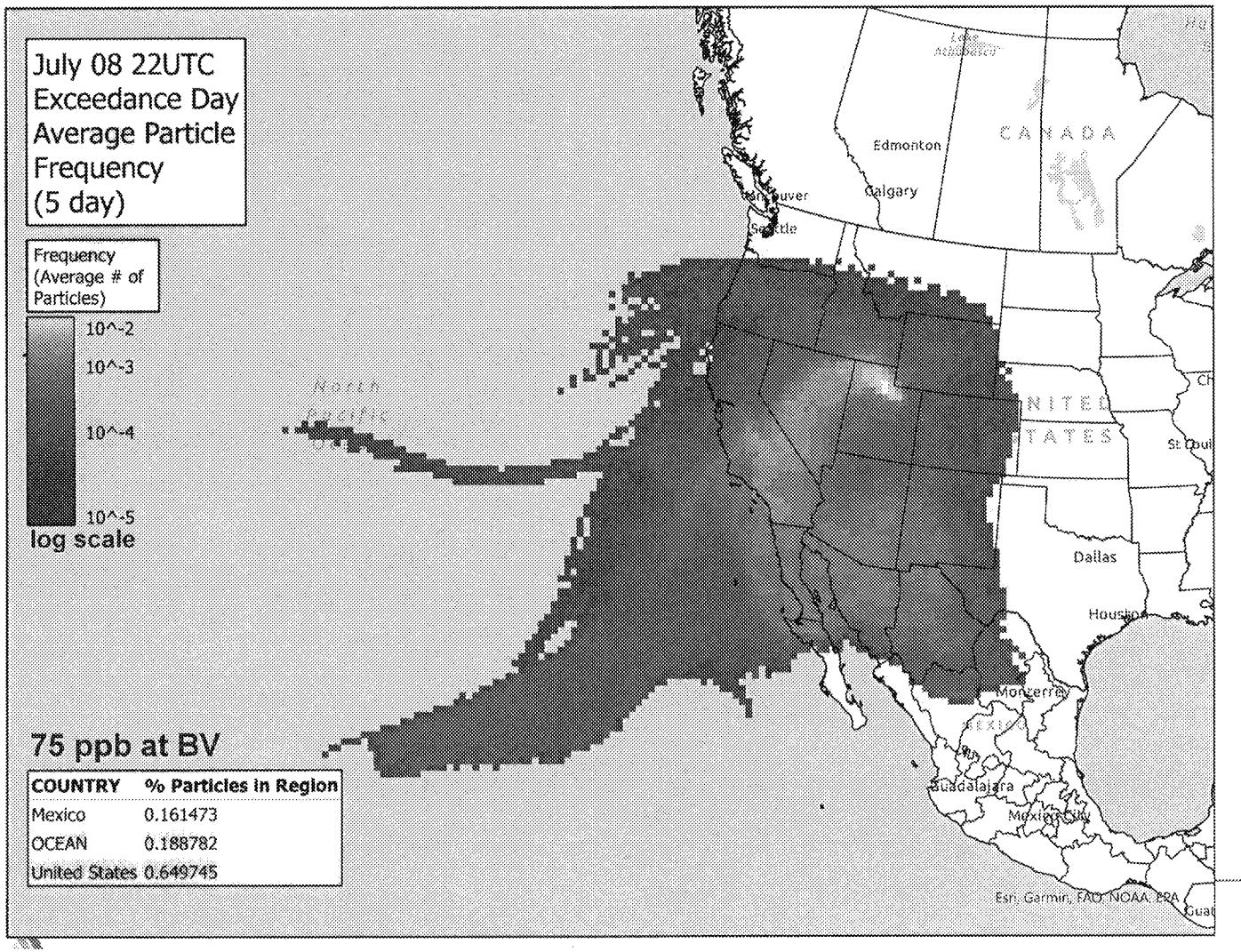
July 7 Average Particle Frequency



COUNTRY	% Particles in Region
Mexico	0.115426
OCEAN	0.218359
United States	0.666214

Exceedance

July 8 Average Particle Frequency



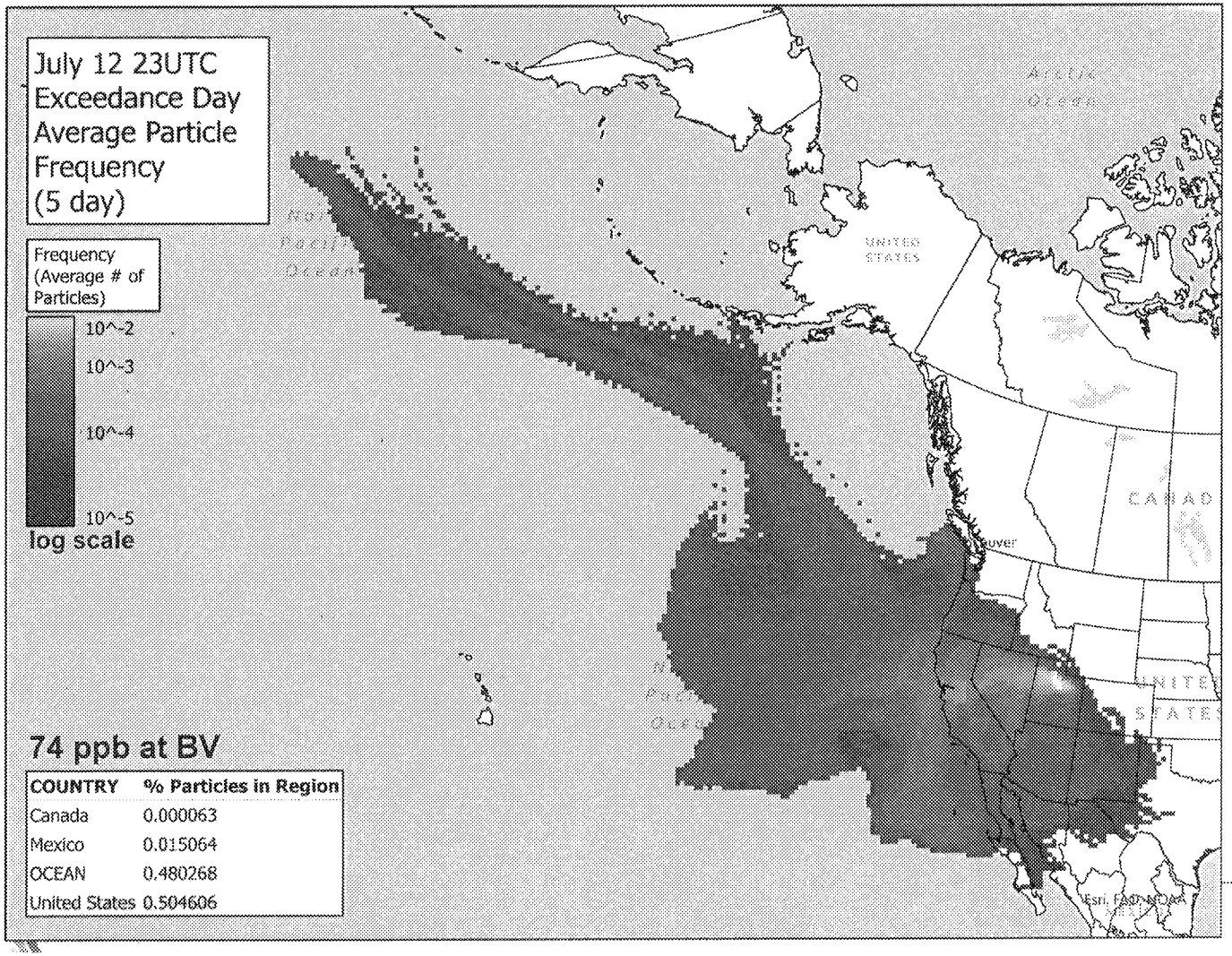
75 ppb at BV

COUNTRY	% Particles in Region
Mexico	0.161473
OCEAN	0.188782
United States	0.649745

Division of Air Quality

Exceedance

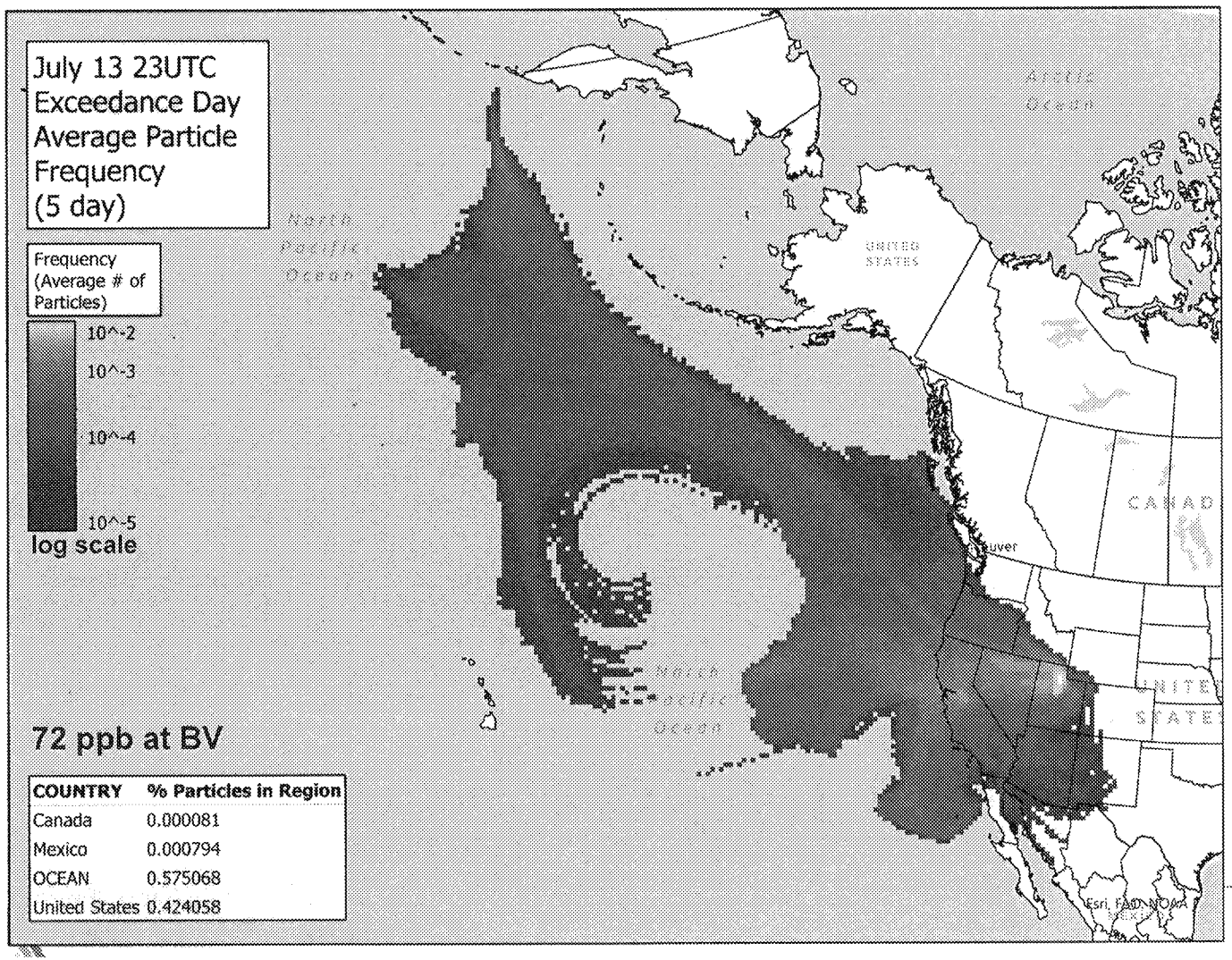
July 12 Average Particle Frequency



Division of Air Quality

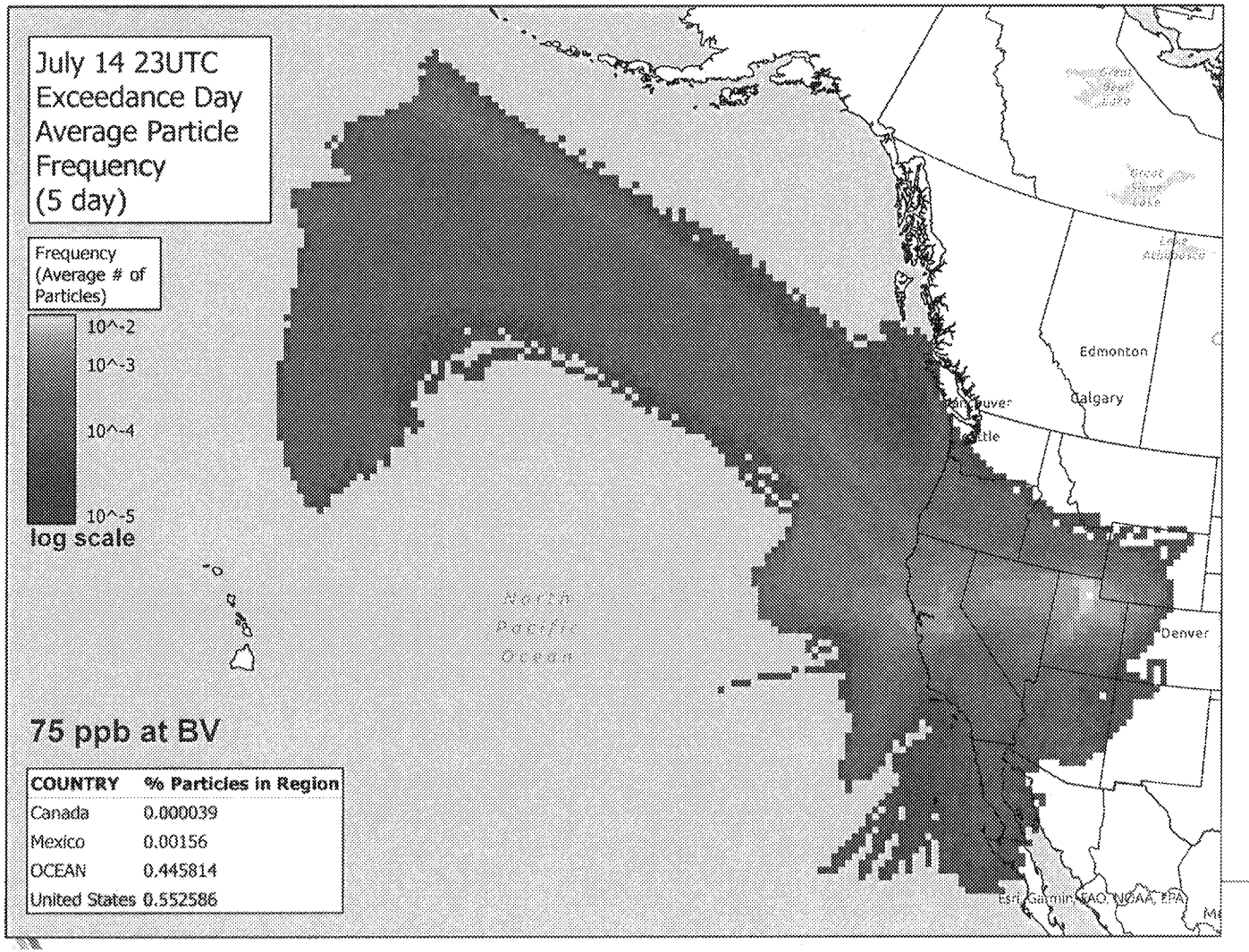
Exceedance

July 13 Average Particle Frequency



Exceedance

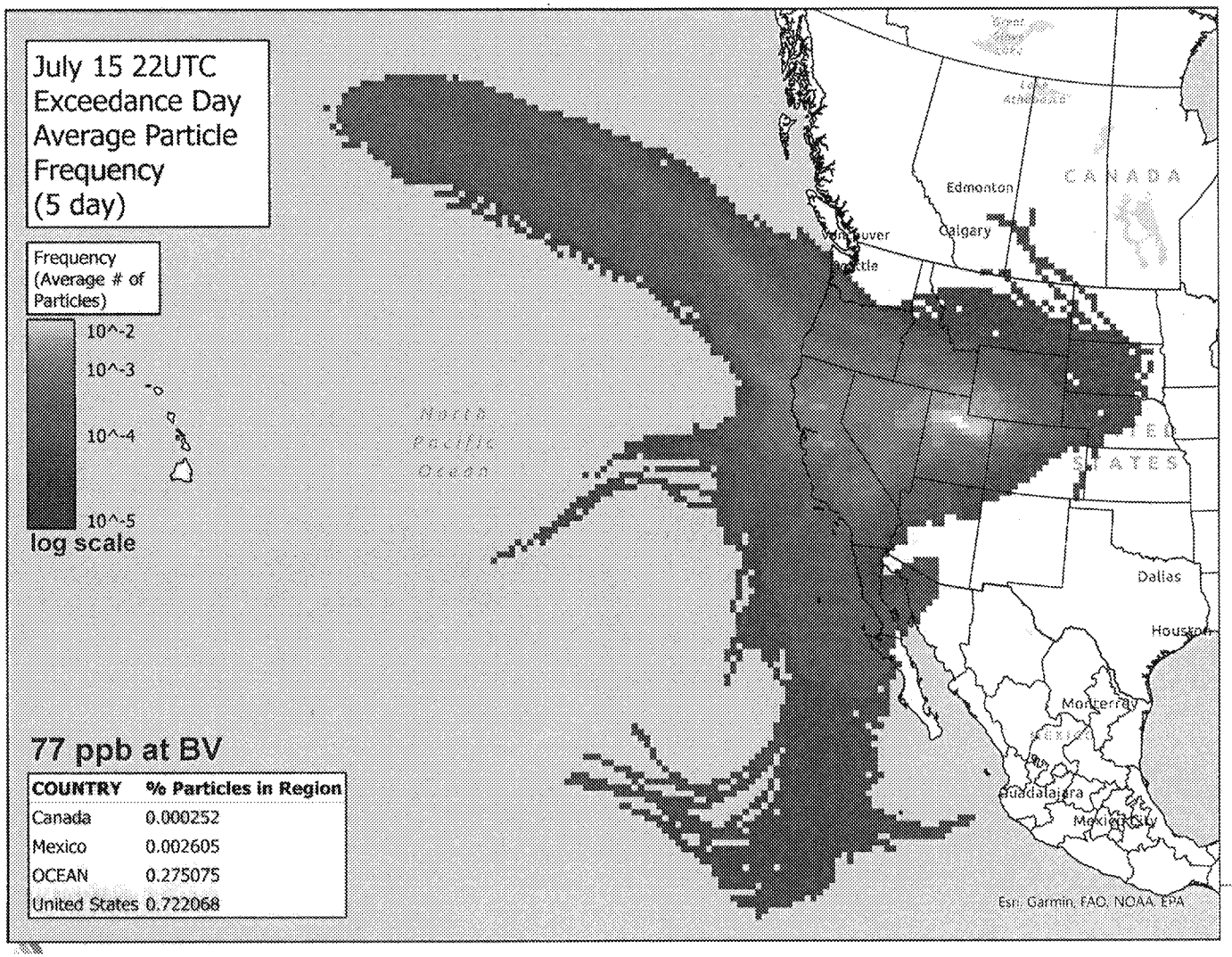
July 14 Average Particle Frequency



Division of Air Quality

Exceedance

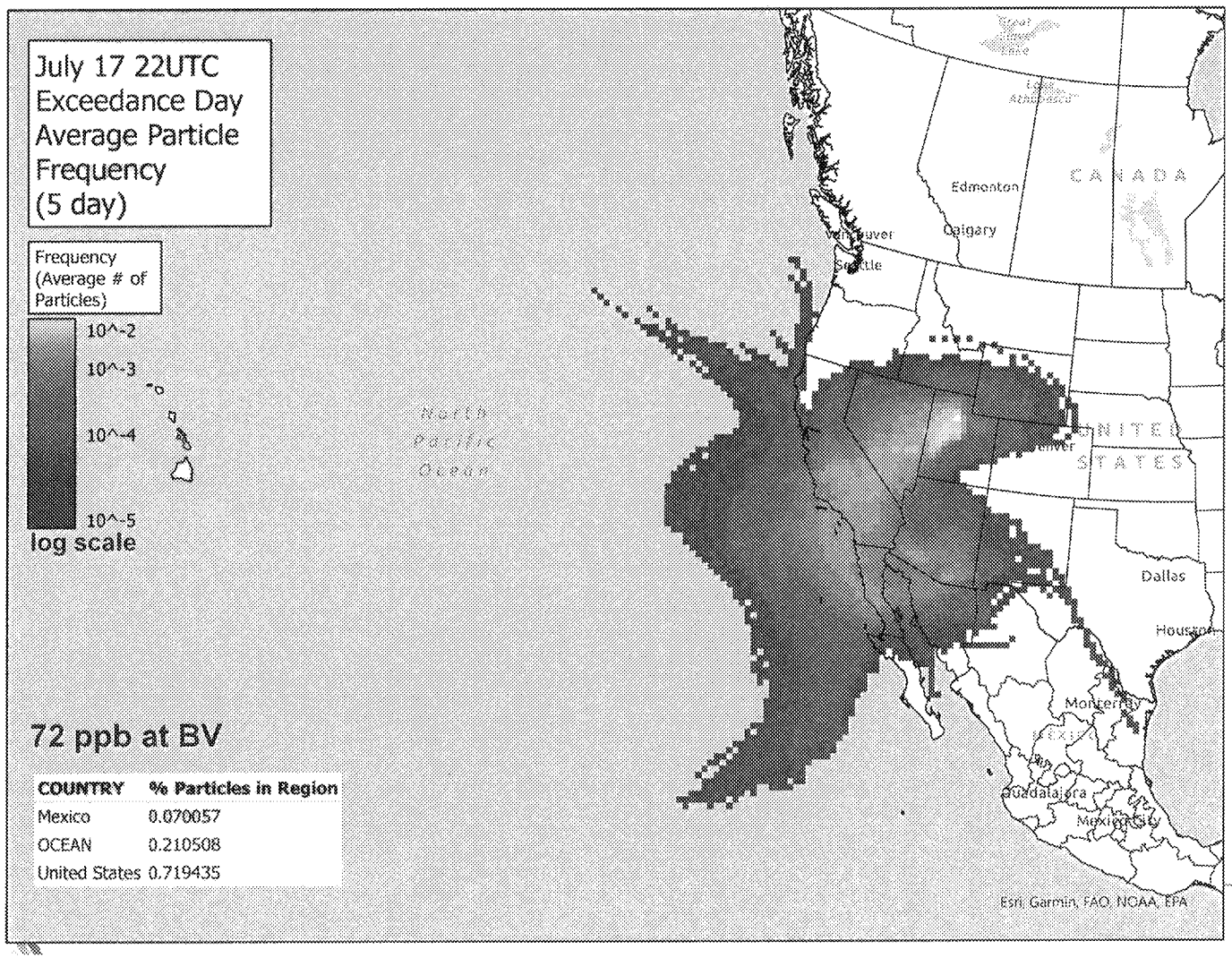
July 15 Average Particle Frequency



Division of Air Quality

Exceedance

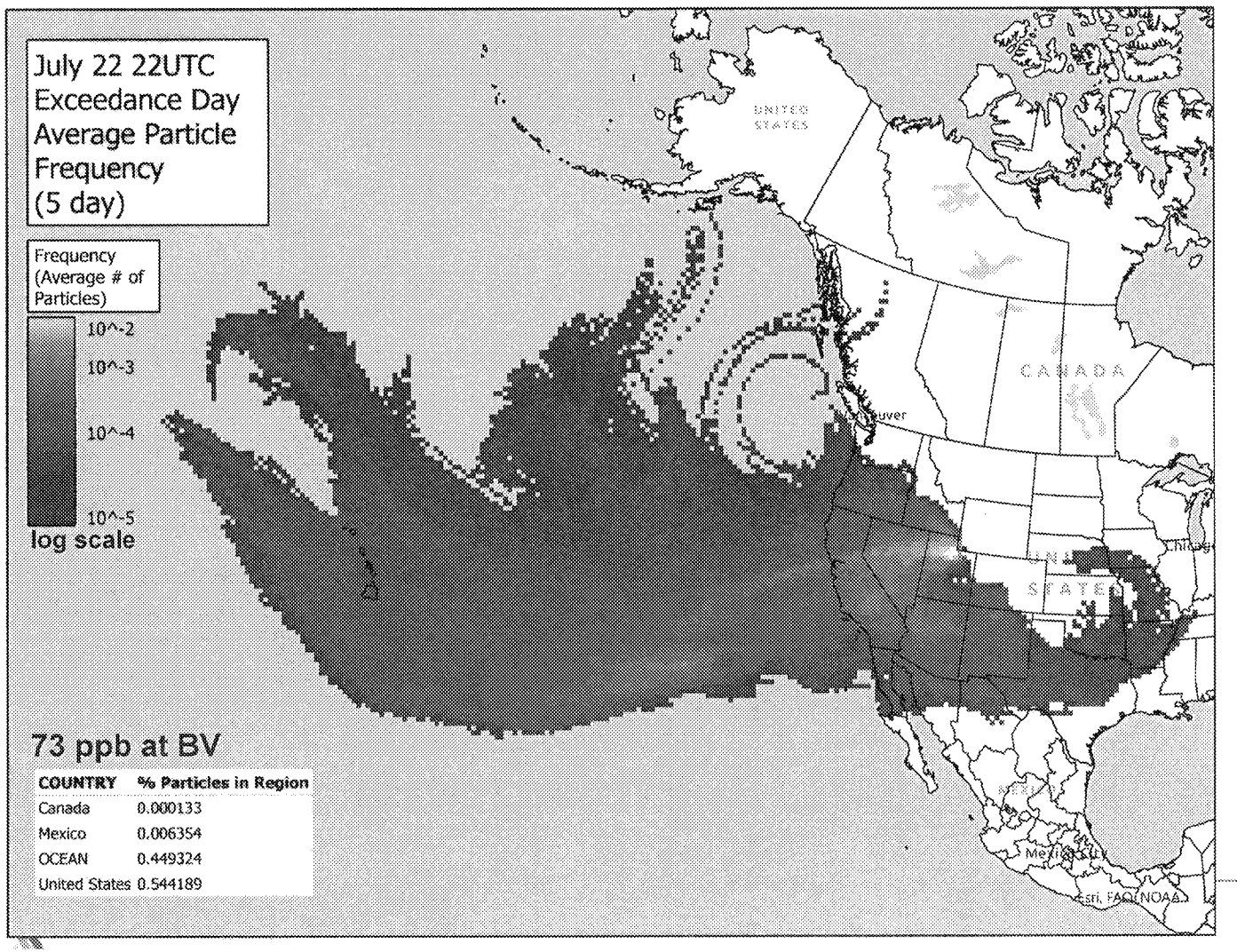
July 17 Average Particle Frequency



Division of Air Quality

Exceedance

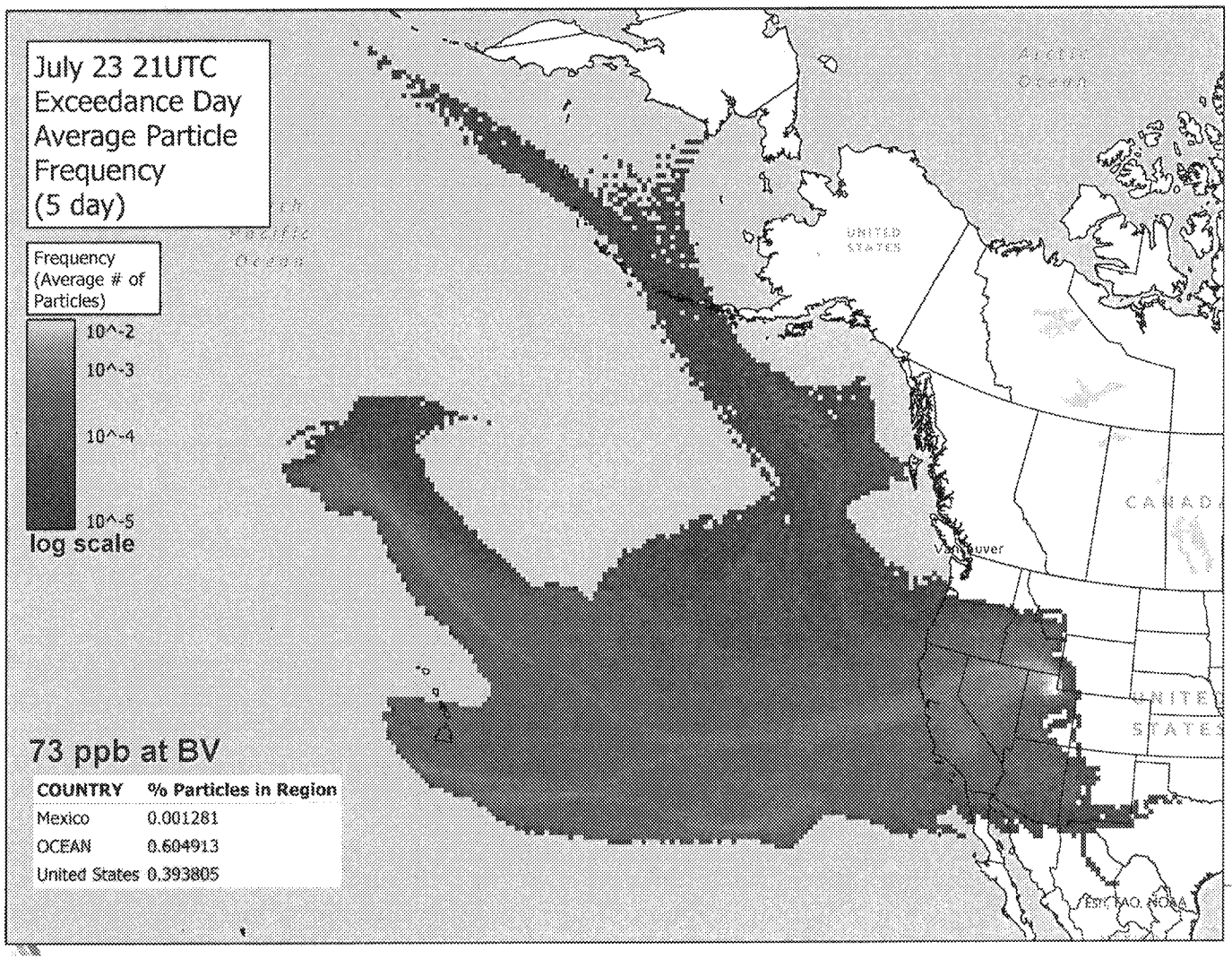
July 22 Average Particle Frequency



Division of Air Quality

Exceedance

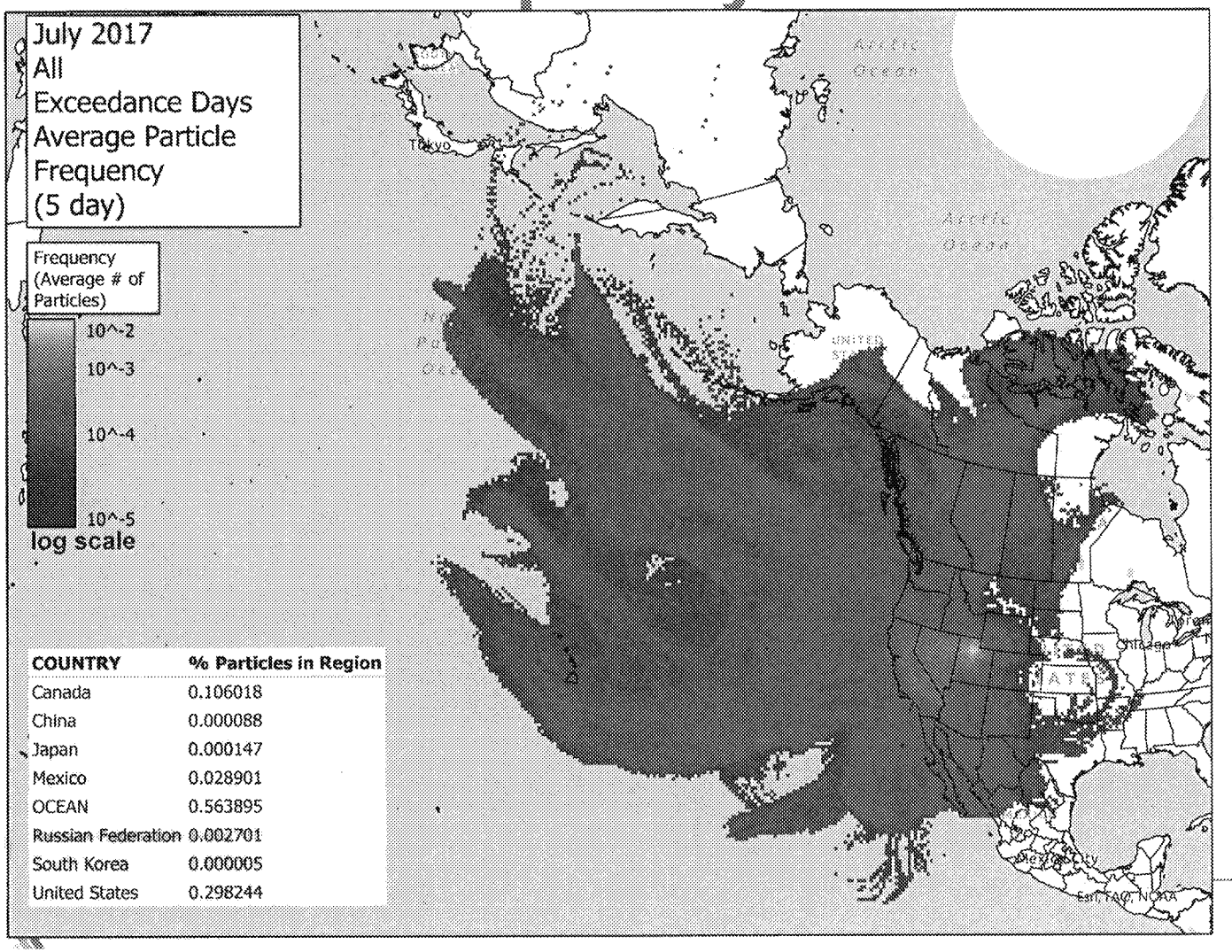
July 23 Average Particle Frequency



Division of Air Quality

Exceedance

July Exceedance Days (all) Average Particle Frequency

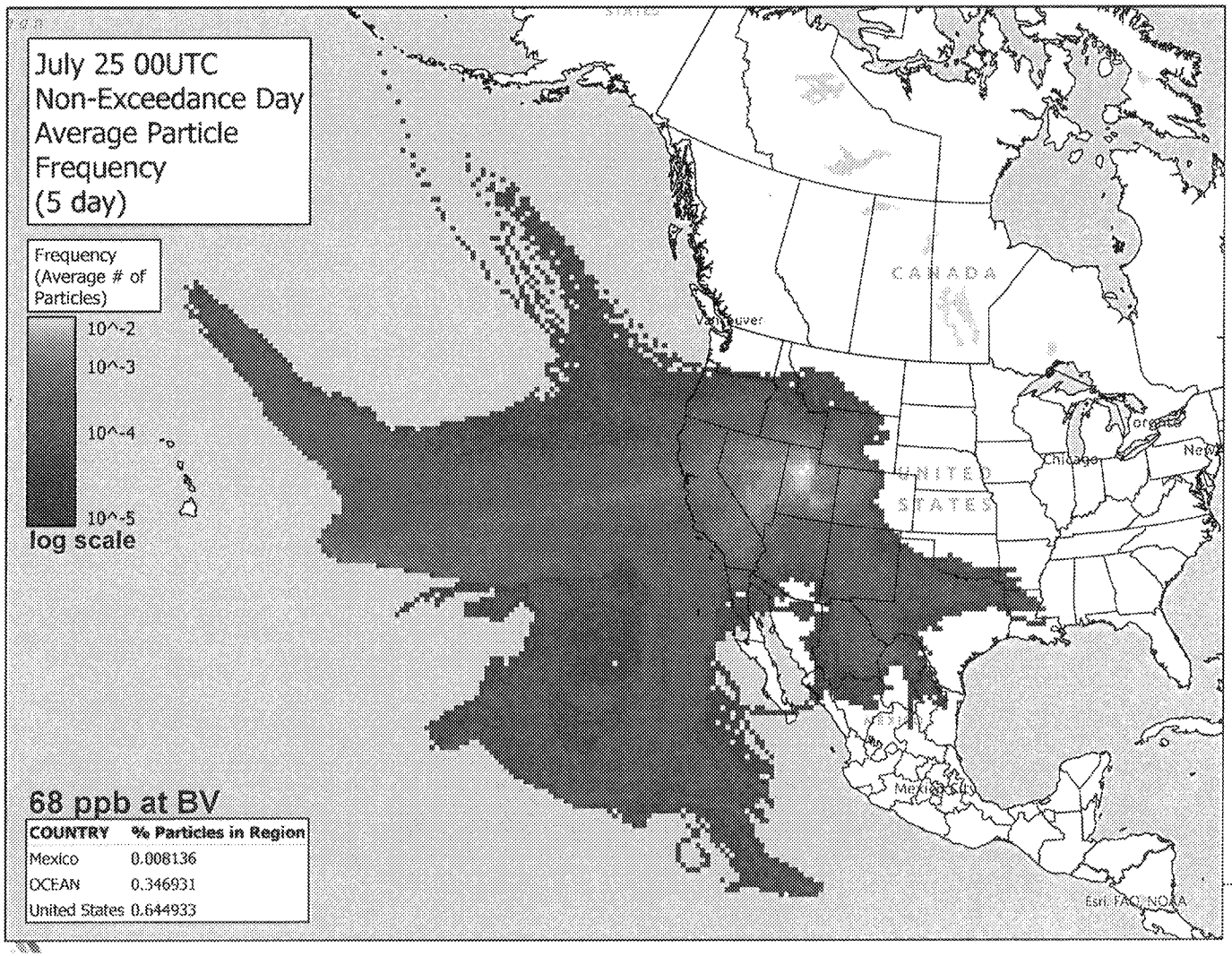


COUNTRY	% Particles in Region
Canada	0.106018
China	0.000088
Japan	0.000147
Mexico	0.028901
OCEAN	0.563895
Russian Federation	0.002701
South Korea	0.000005
United States	0.298244

Division of Air Quality

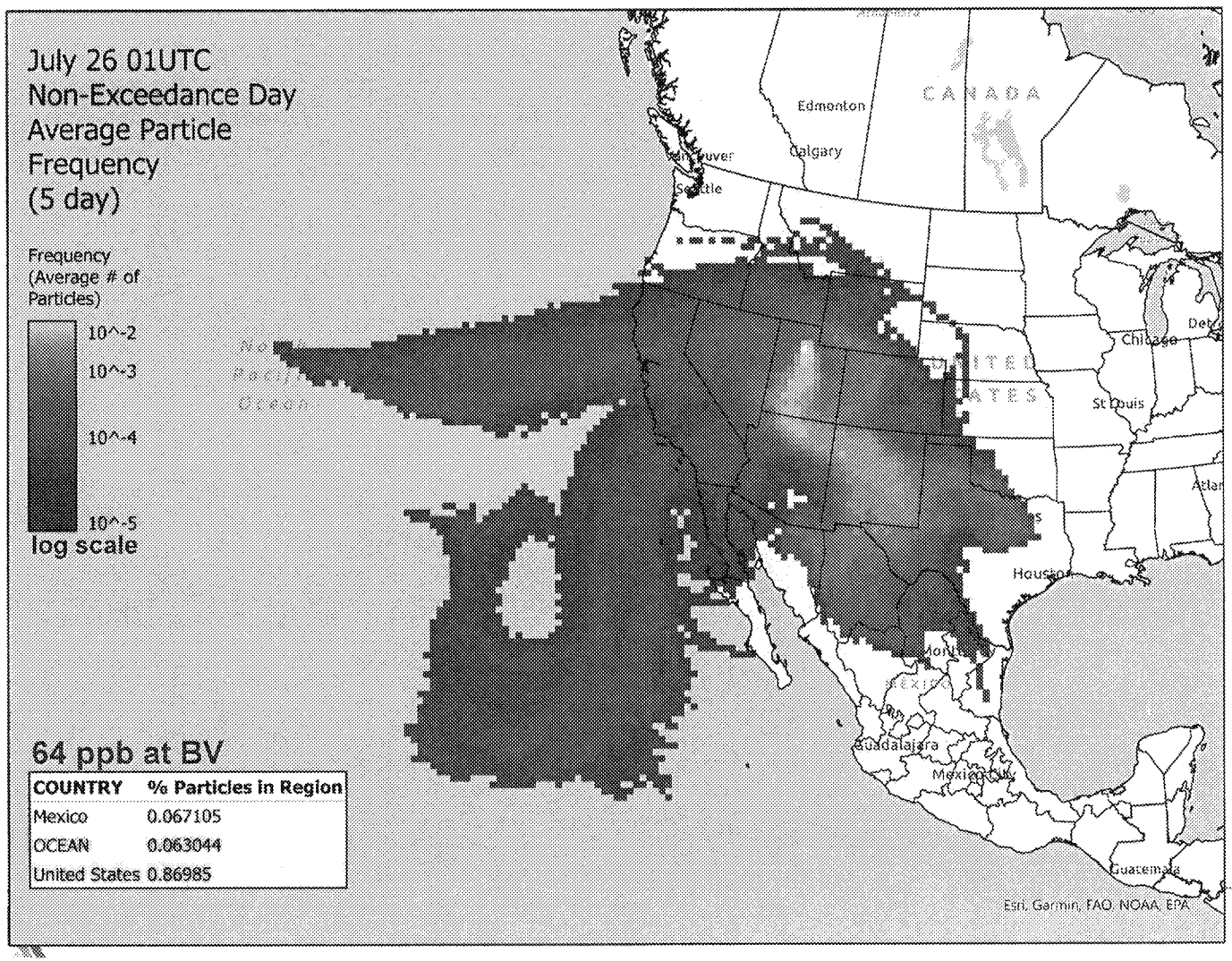
Non-Exceedance

July 25 Average Particle Frequency



Non-Exceedance

July 26 Average Particle Frequency

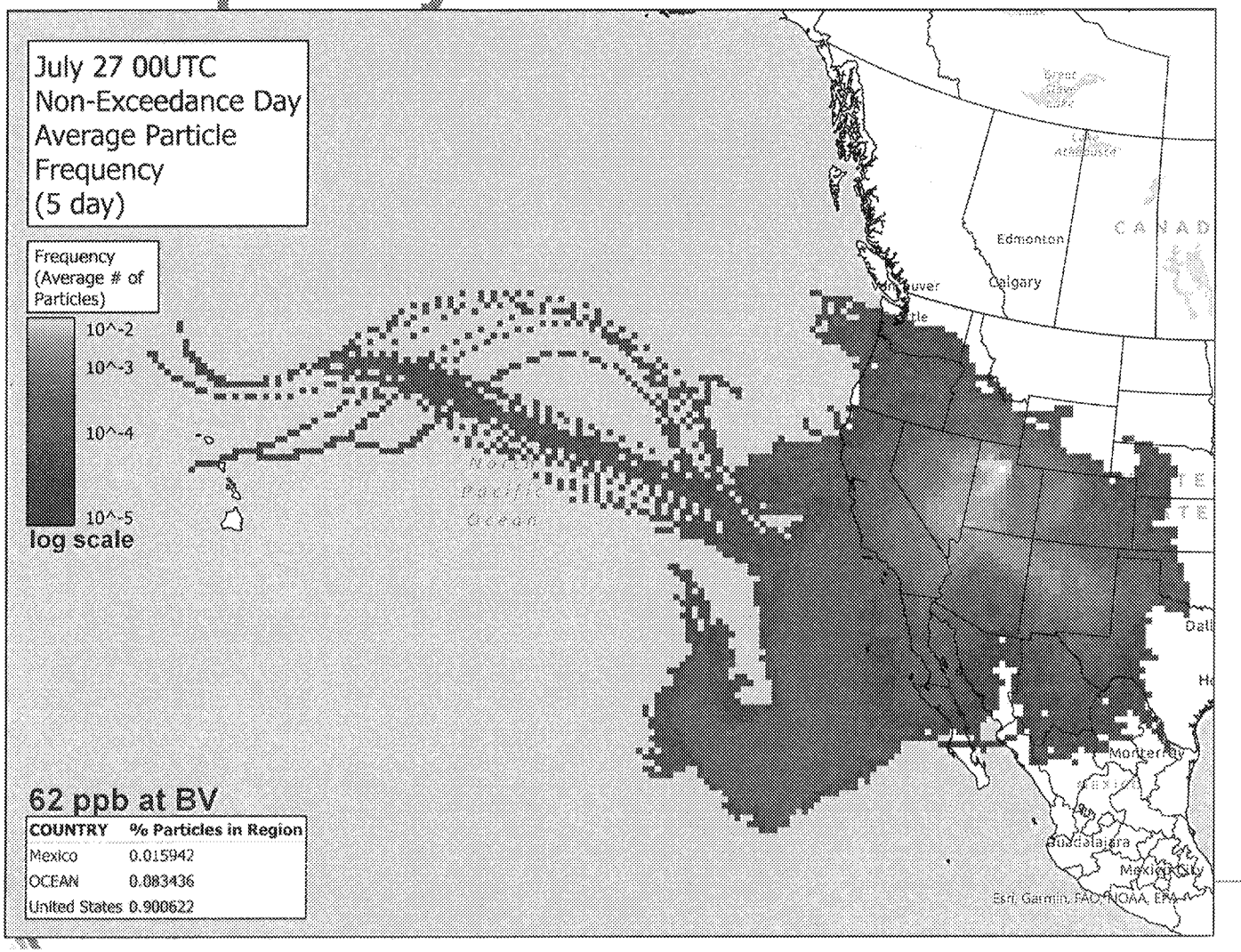


64 ppb at BV

COUNTRY	% Particles in Region
Mexico	0.067105
OCEAN	0.063044
United States	0.86985

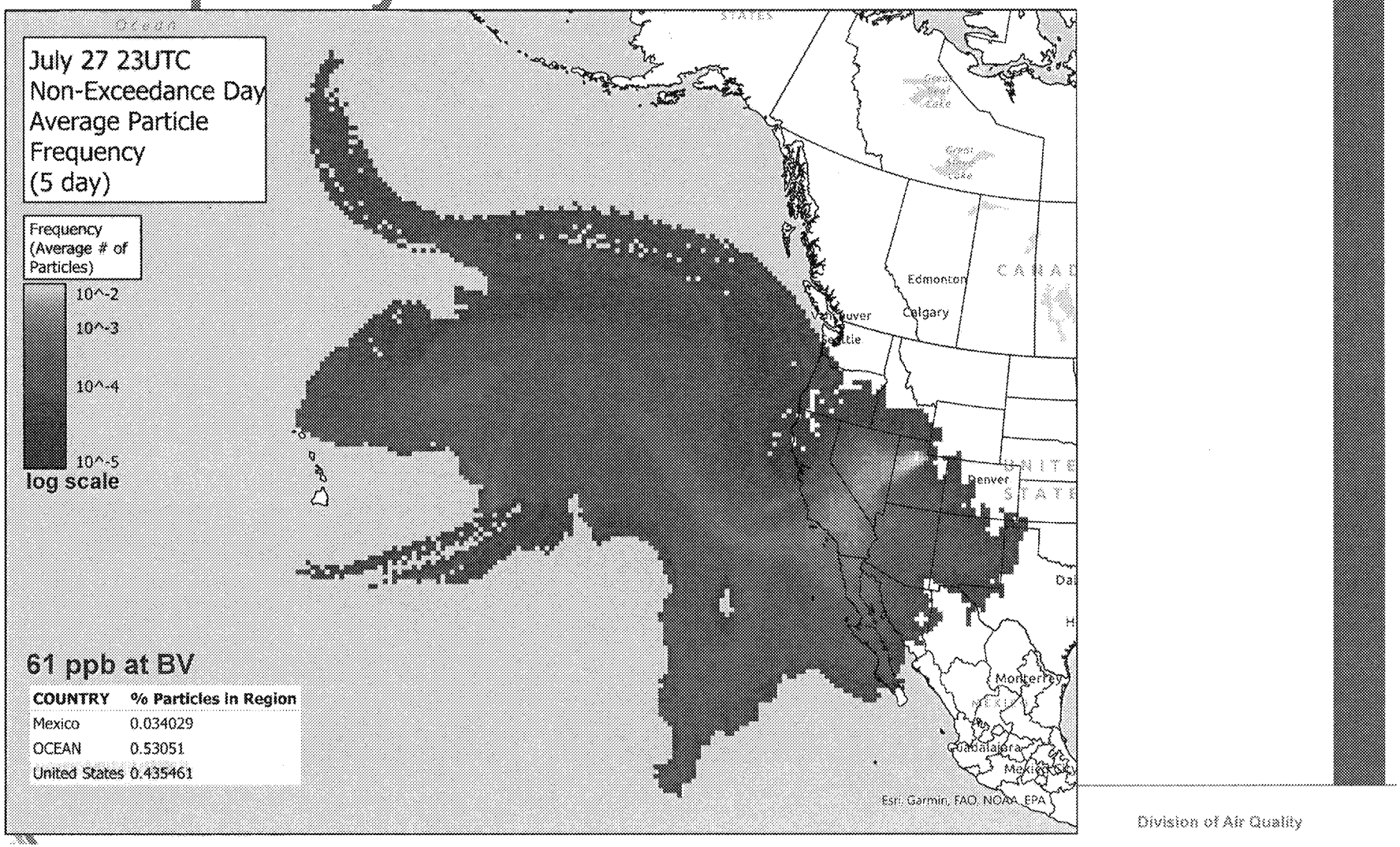
Division of Air Quality

Non-Exceedance
July 27-00UTC Average Particle Frequency



Division of Air Quality

Non-Exceedance
July 27-23UTC Average Particle Frequency

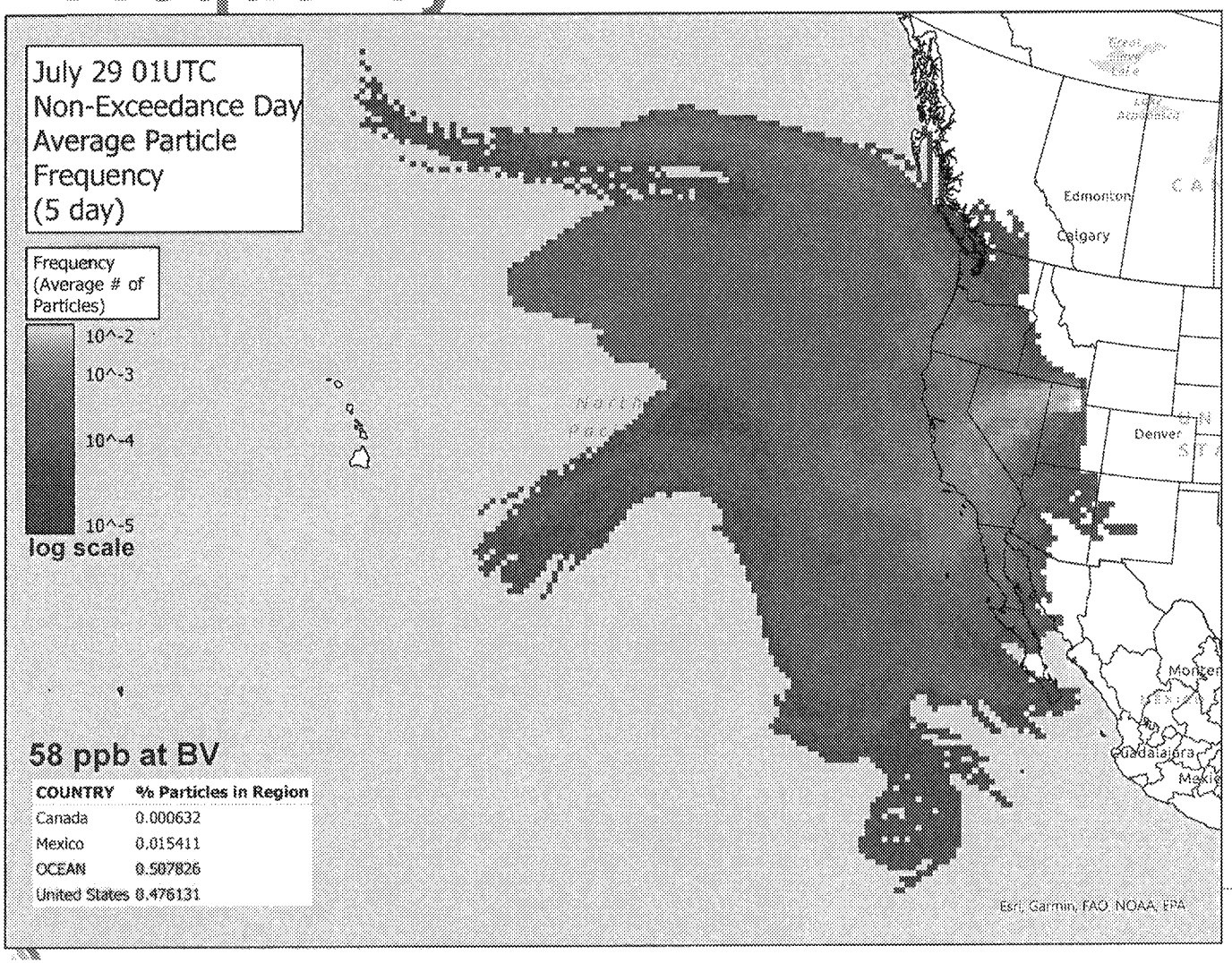


61 ppb at BV

COUNTRY	% Particles in Region
Mexico	0.034029
OCEAN	0.53051
United States	0.435461

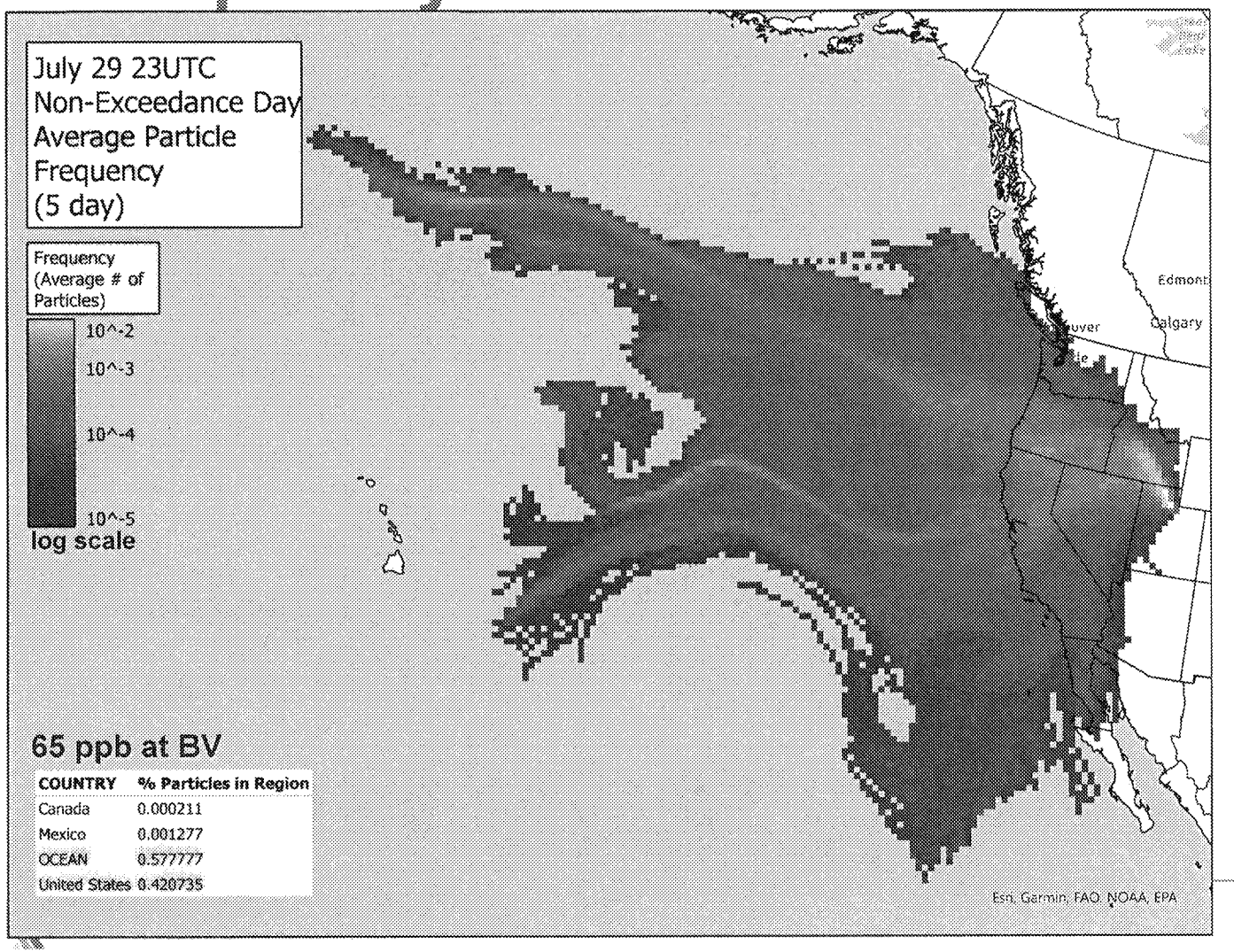
Division of Air Quality

Non-Exceedance
July 29-01UTC Average Particle Frequency



Division of Air Quality

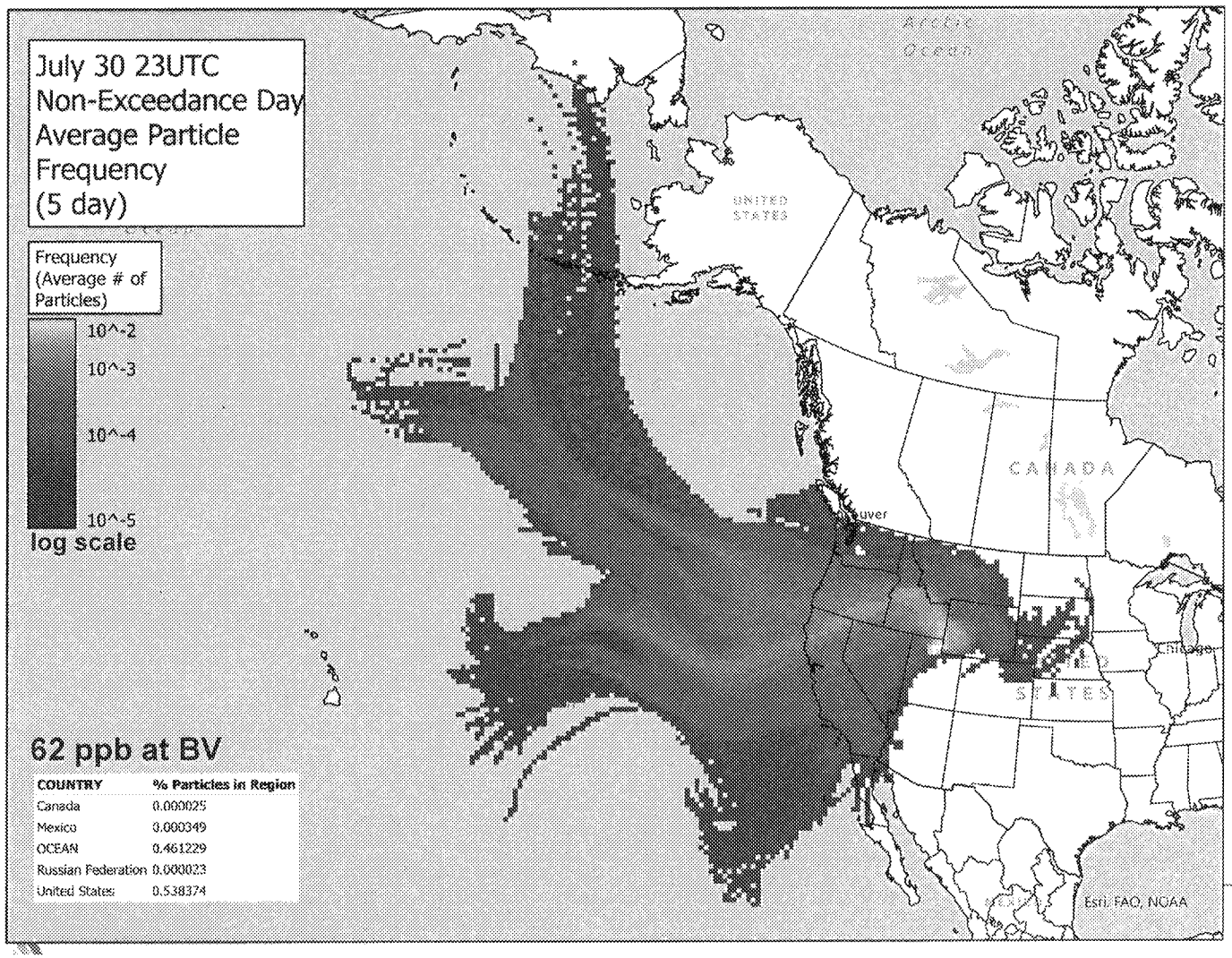
Non-Exceedance
July 29-23UTC Average Particle Frequency



Division of Air Quality

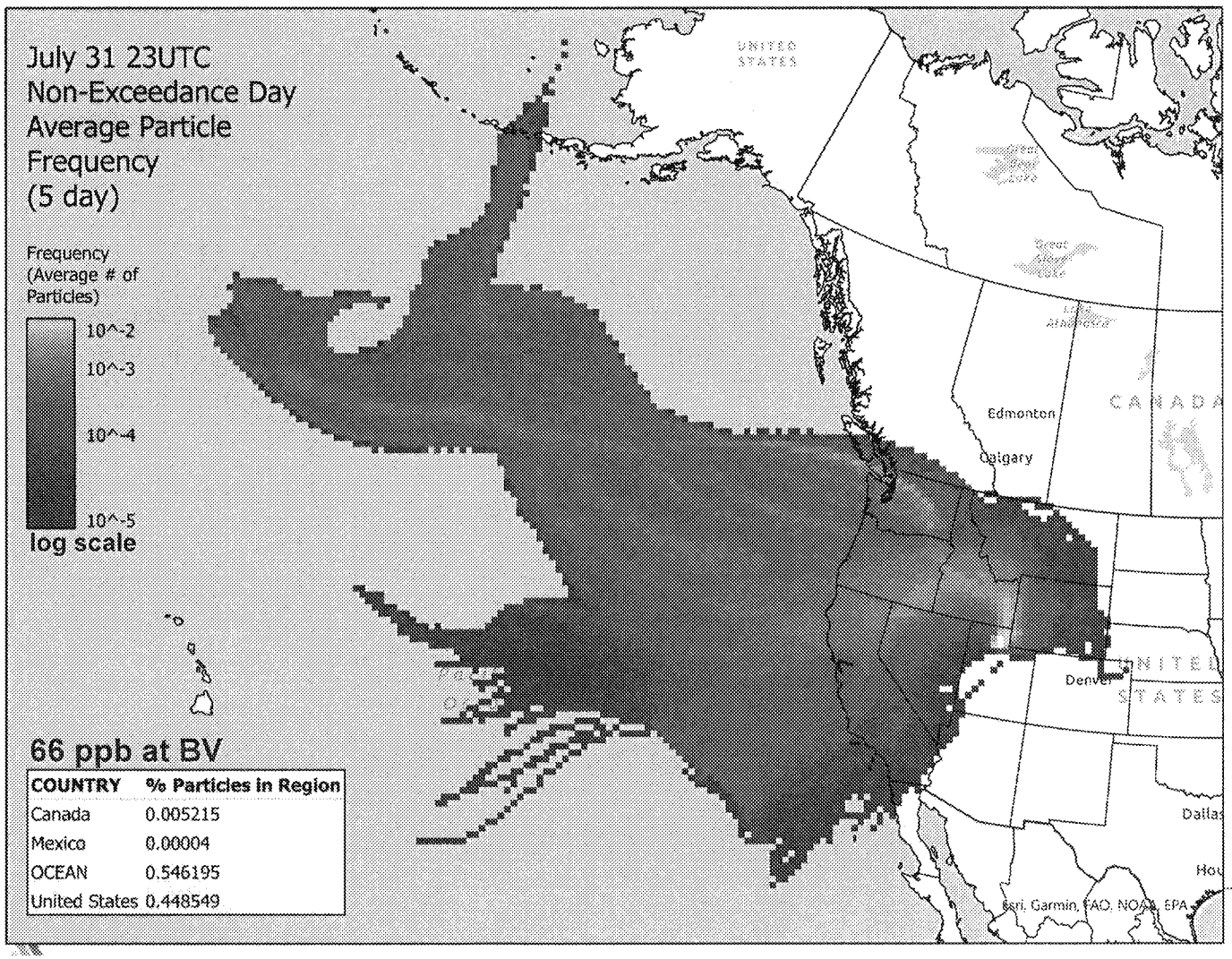
Non-Exceedance

July 30 Average Particle Frequency



Non-Exceedance

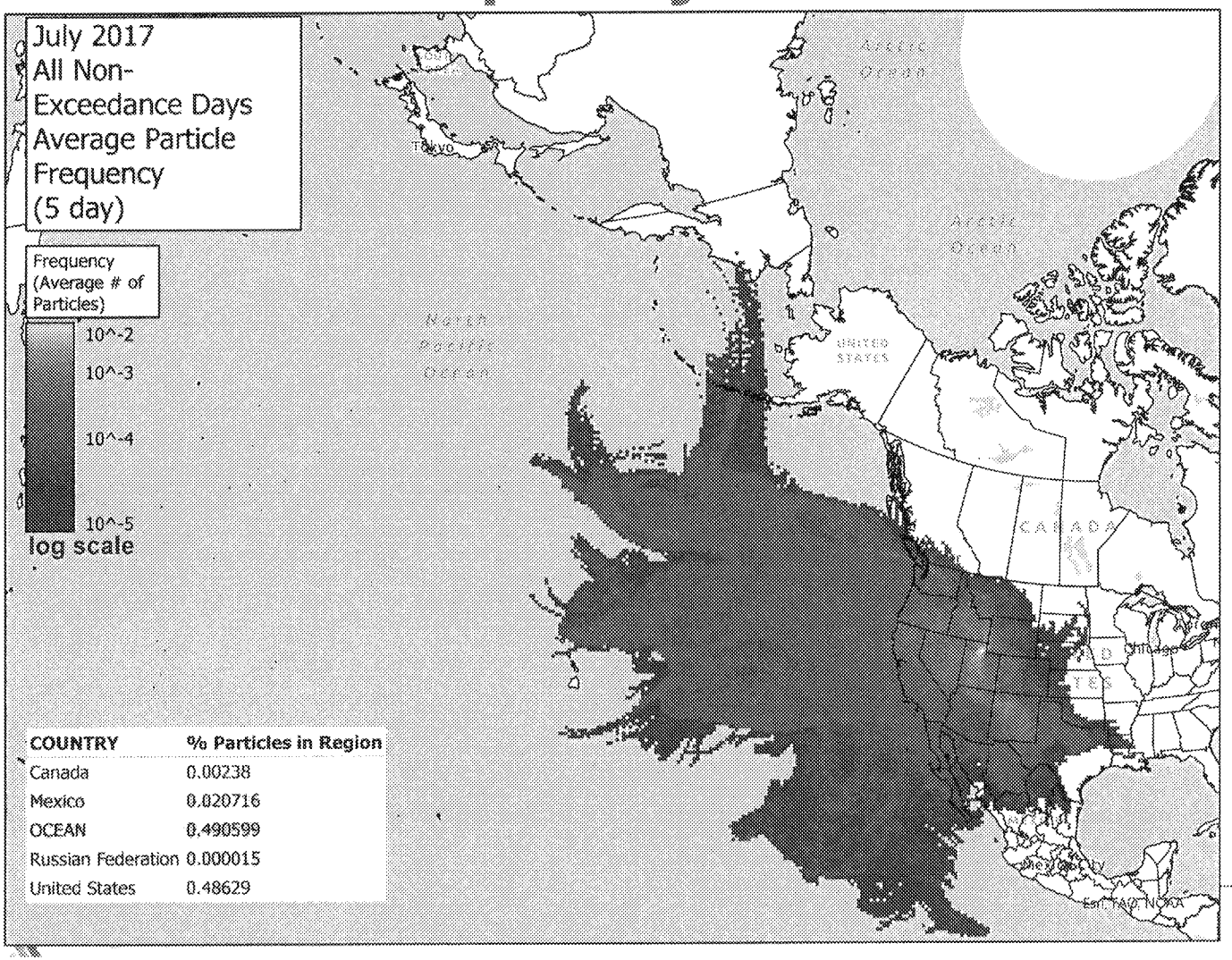
July 31 Average Particle Frequency



COUNTRY	% Particles in Region
Canada	0.005215
Mexico	0.00004
OCEAN	0.546195
United States	0.448549

Non-Exceedance

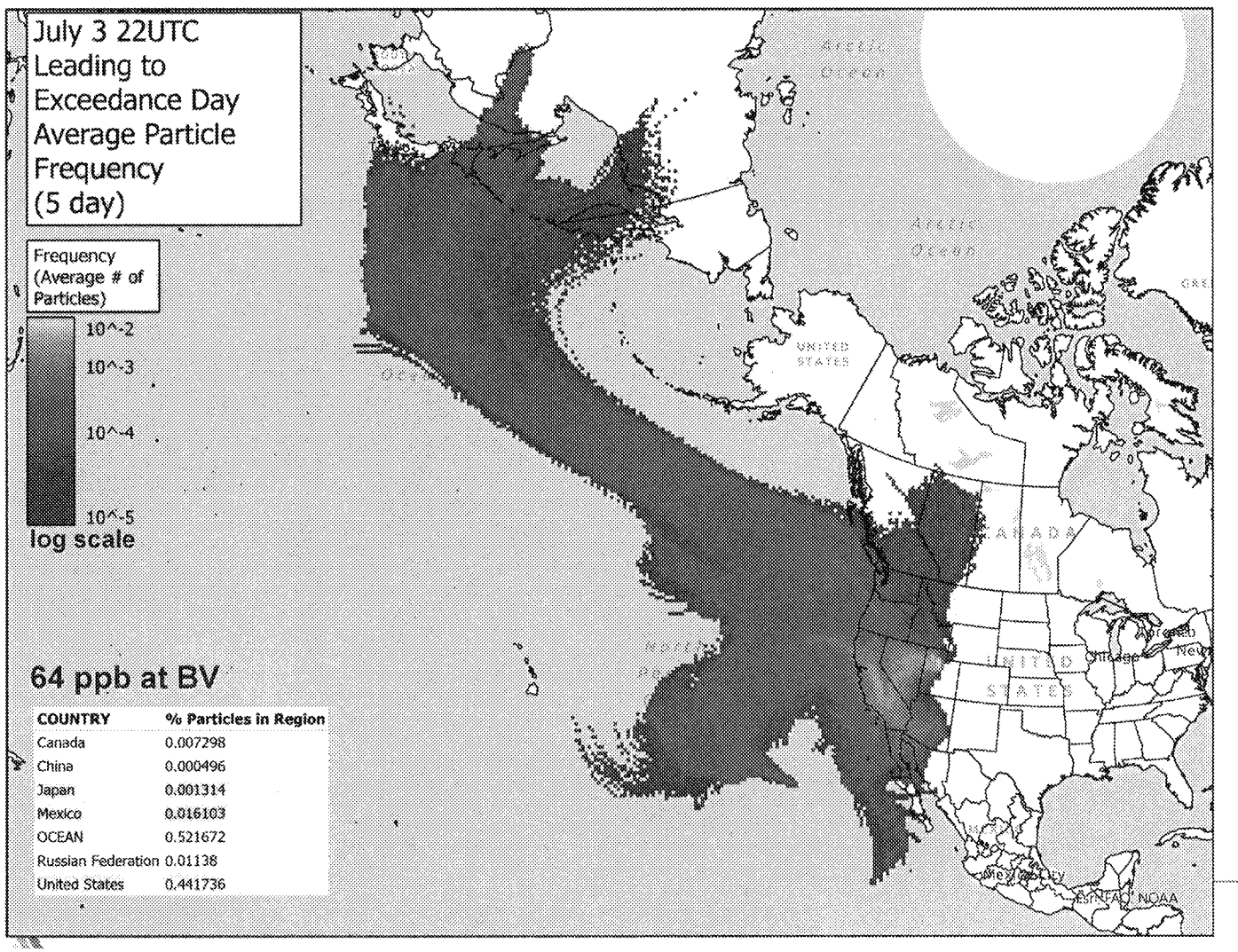
July Non-Exceedance Days (all) Average Particle Frequency



Division of Air Quality

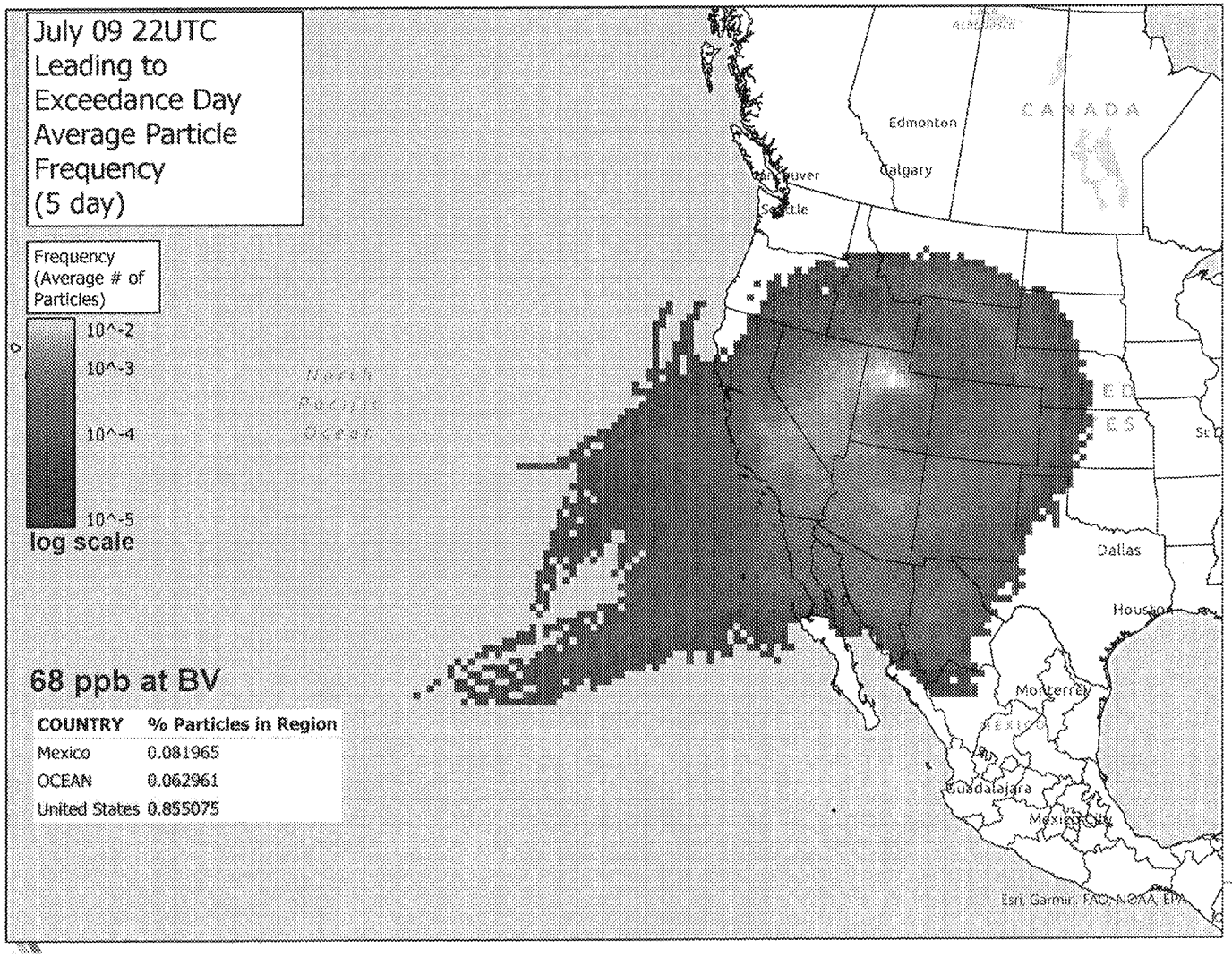
Leading to Exceedance

July 03 Average Particle Frequency



Leading to Exceedance

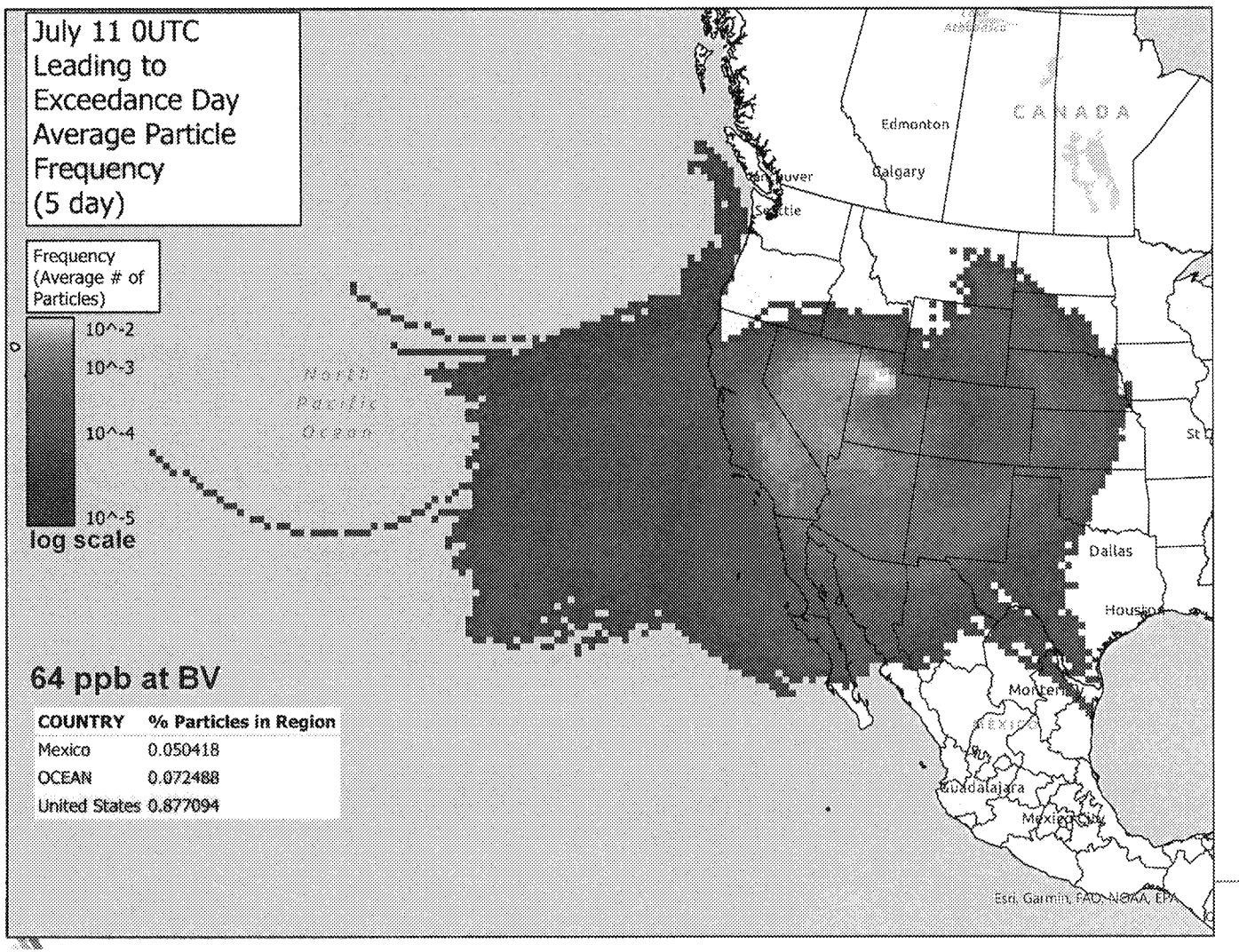
July 09 Average Particle Frequency



Division of Air Quality

Leading to Exceedance

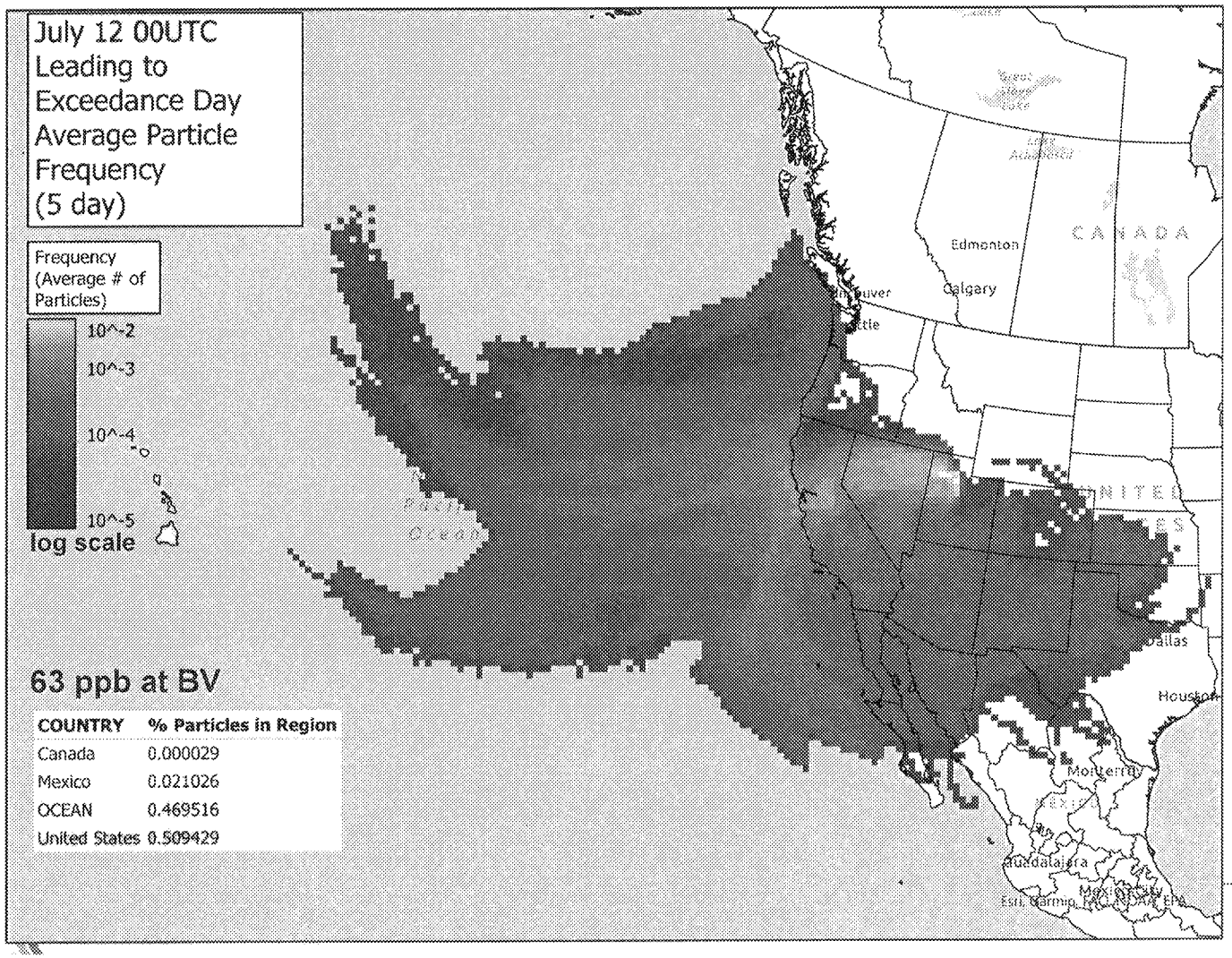
July 11 Average Particle Frequency



Division of Air Quality

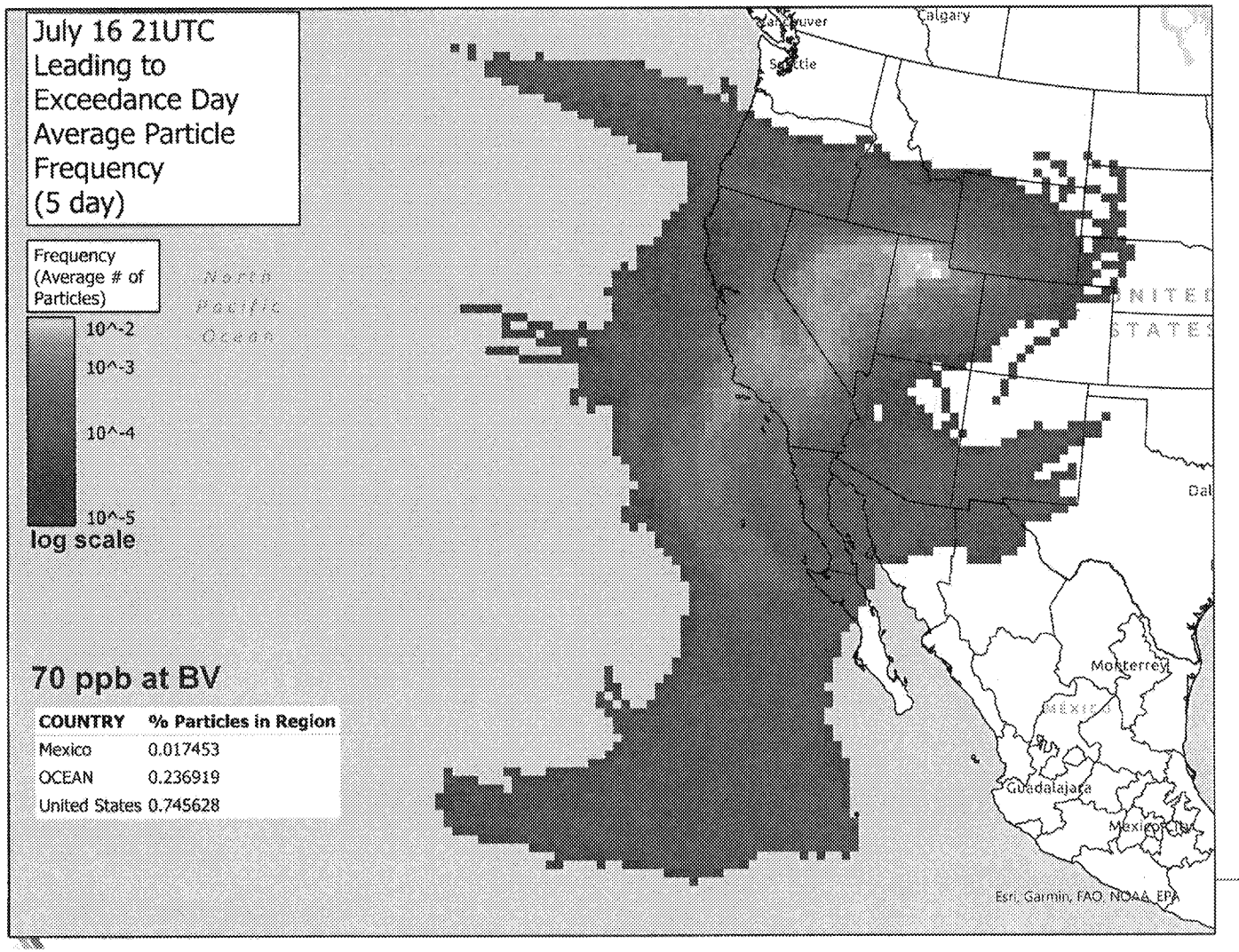
Leading to Exceedance

July 12 Average Particle Frequency



Leading to Exceedance

July 16 Average Particle Frequency



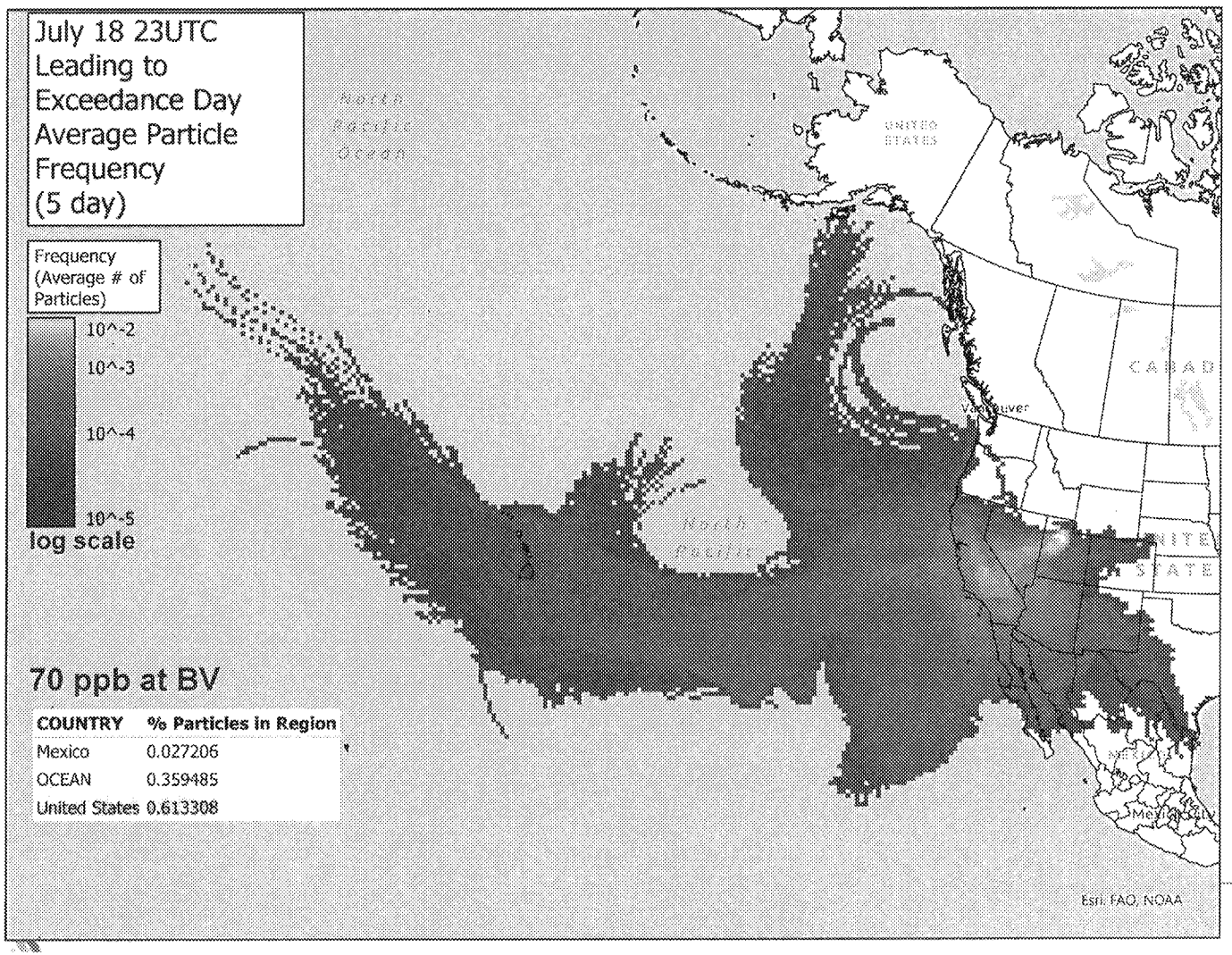
70 ppb at BV

COUNTRY	% Particles in Region
Mexico	0.017453
OCEAN	0.236919
United States	0.745628

Division of Air Quality

Leading to Exceedance

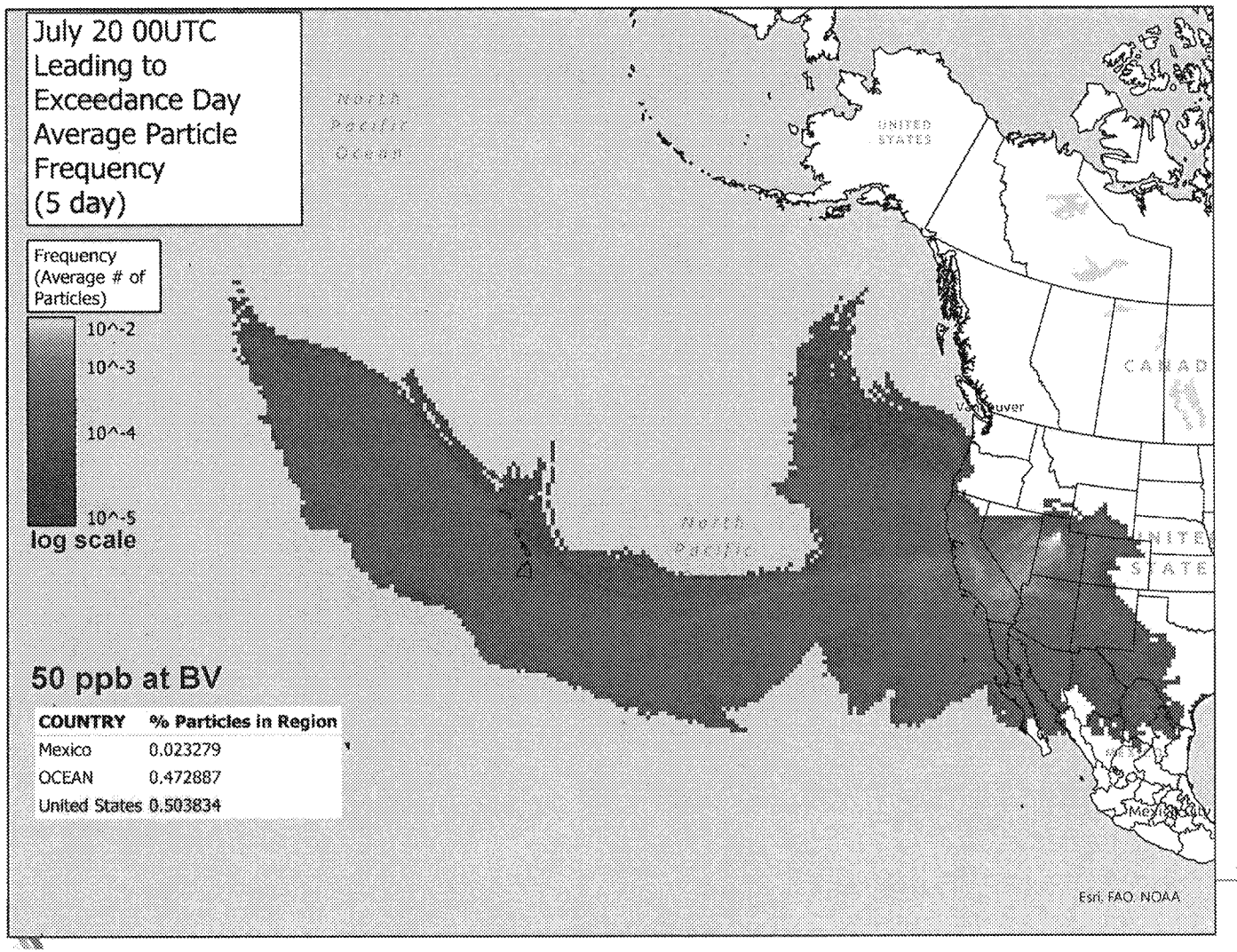
July 18 Average Particle Frequency



Division of Air Quality

Leading to Exceedance

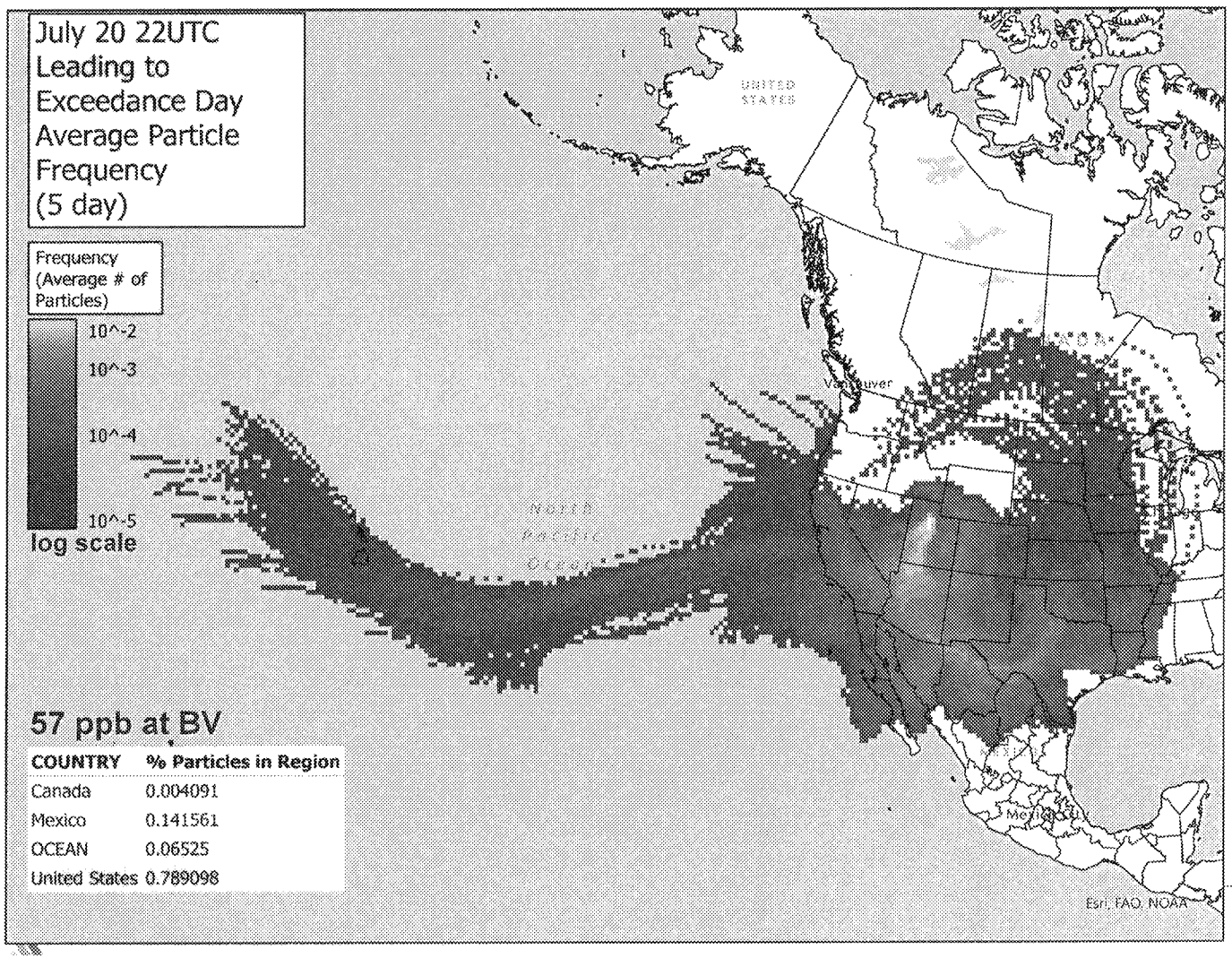
July 20-00UTC Average Particle Frequency



Division of Air Quality

Leading to Exceedance

July 20-22UTC Average Particle Frequency

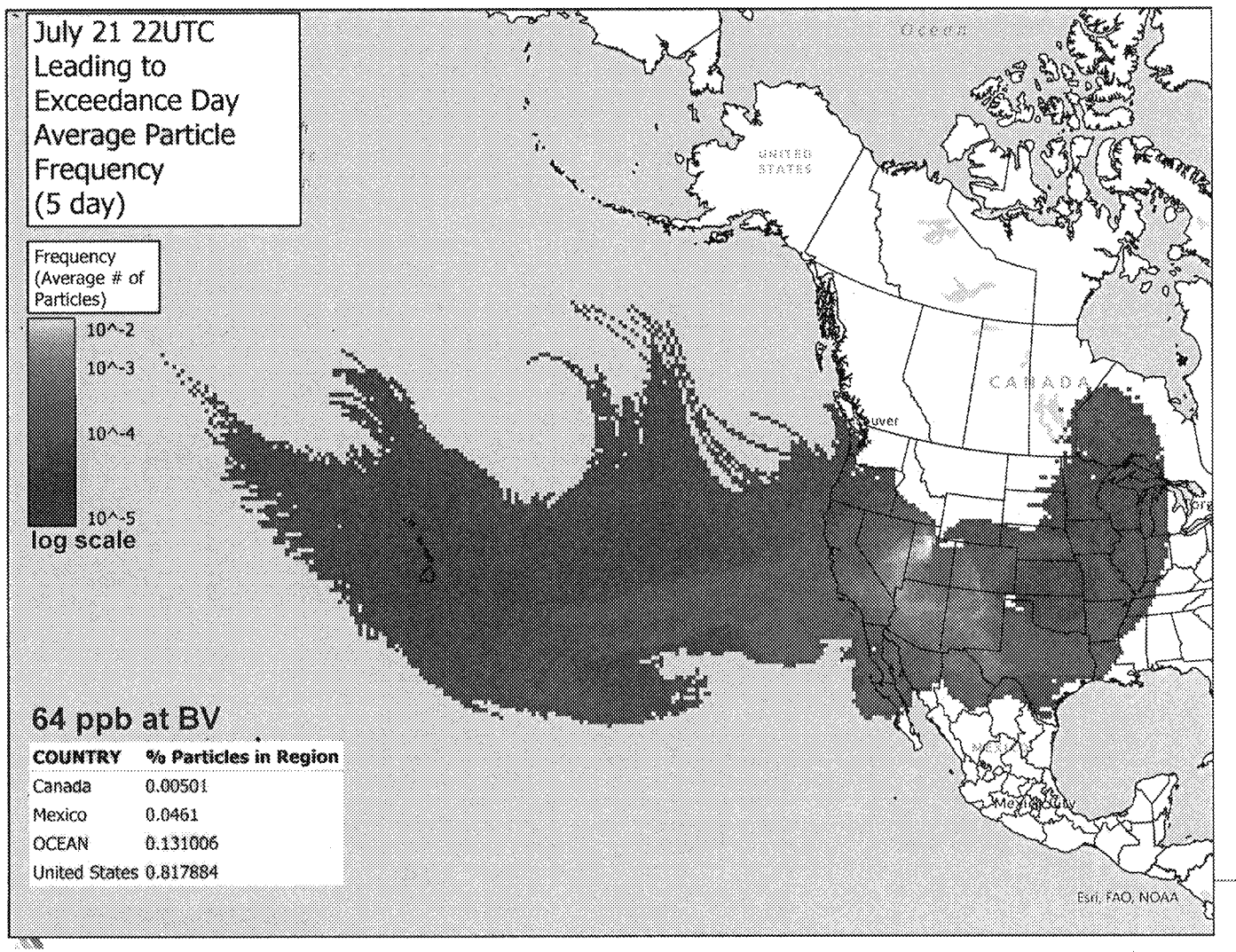


57 ppb at BV

COUNTRY	% Particles in Region
Canada	0.004091
Mexico	0.141561
OCEAN	0.06525
United States	0.789098

Leading to Exceedance

July 21 Average Particle Frequency

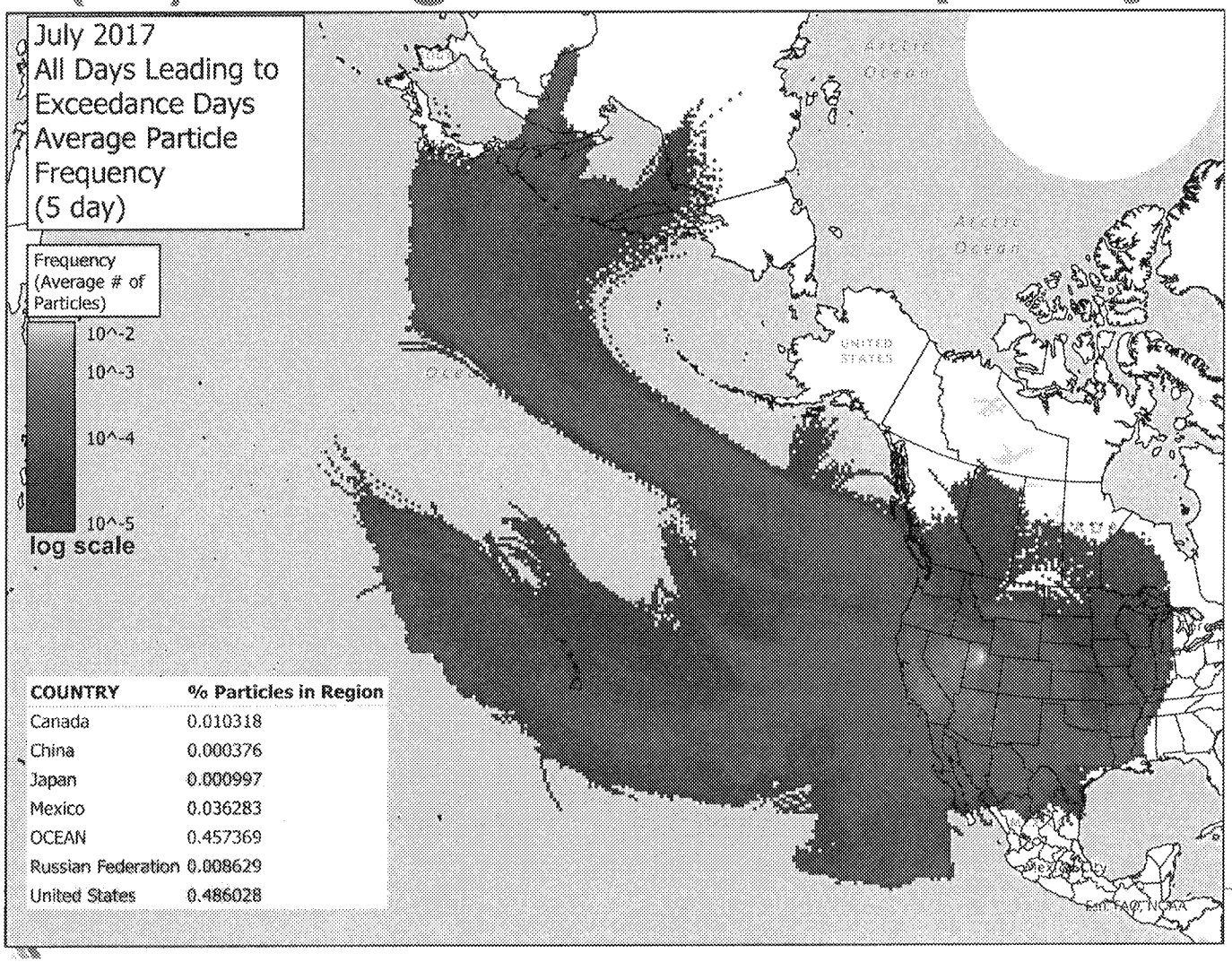


64 ppb at BV

COUNTRY	% Particles in Region
Canada	0.00501
Mexico	0.0461
OCEAN	0.131006
United States	0.817884

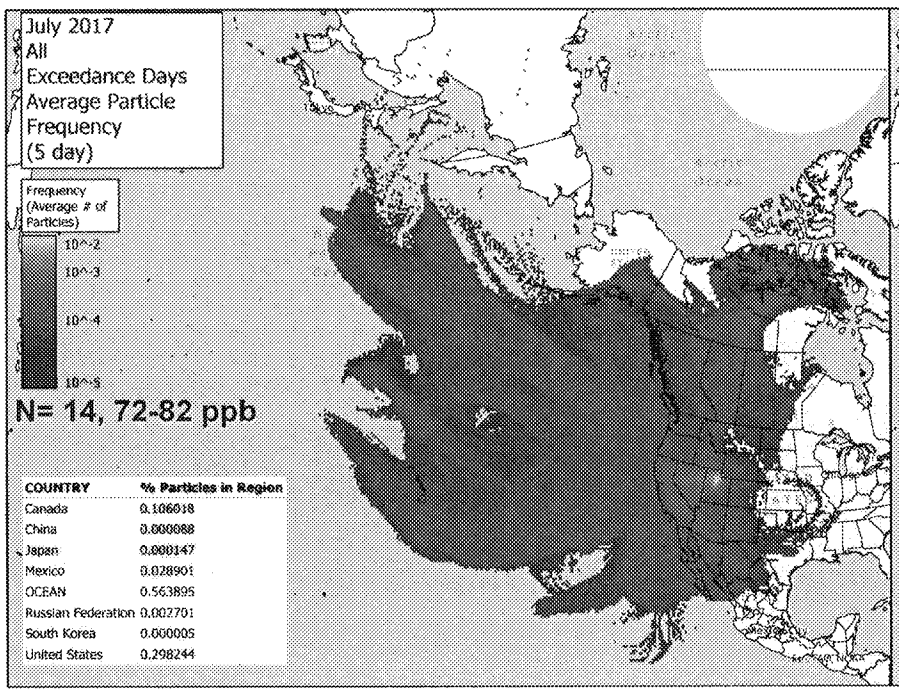
Leading to Exceedance

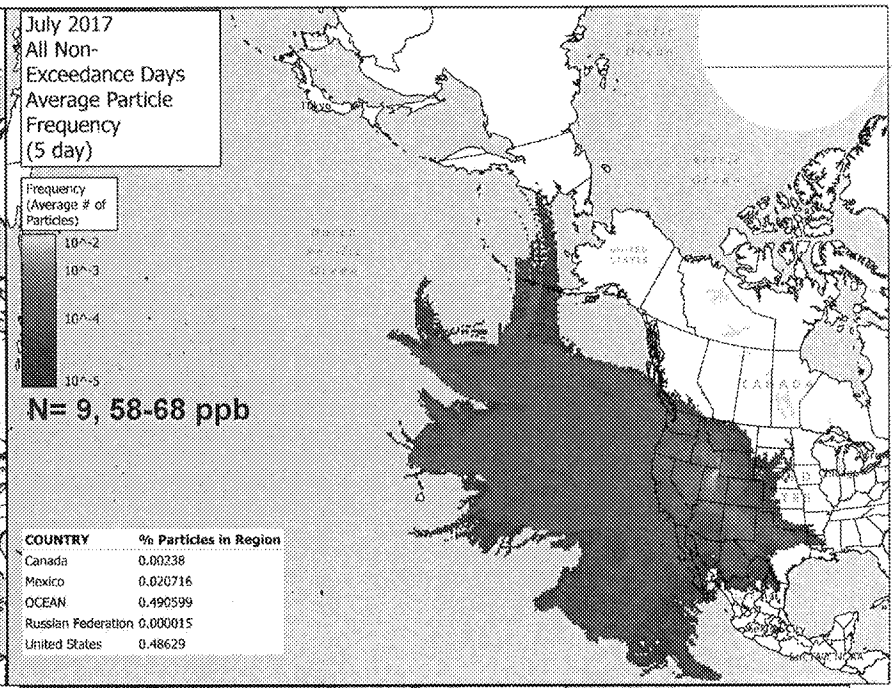
July Leading to Exceedance Days (all) Average Particle Frequency

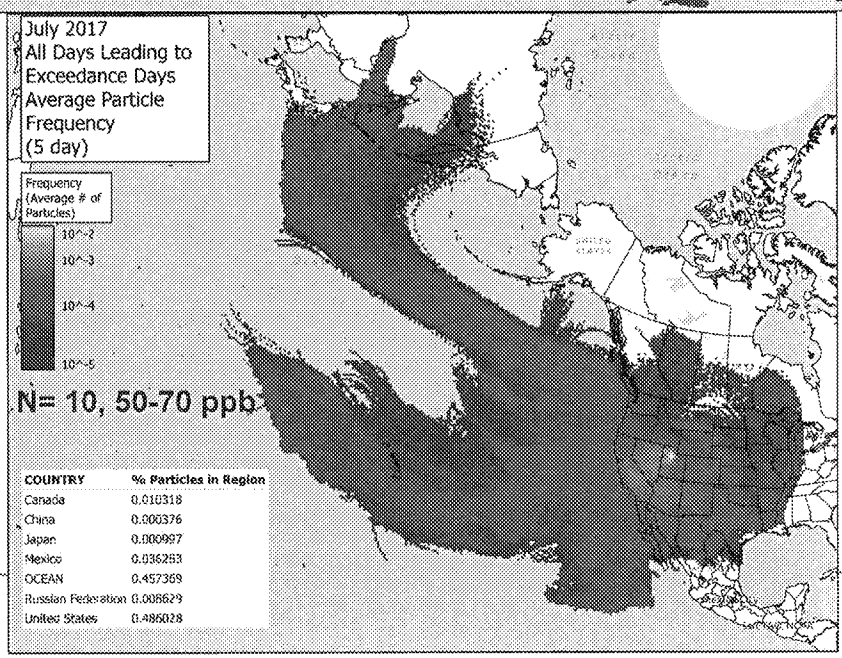


COUNTRY	% Particles in Region
Canada	0.010318
China	0.000376
Japan	0.000997
Mexico	0.036283
OCEAN	0.457369
Russian Federation	0.008629
United States	0.486028

Division of Air Quality

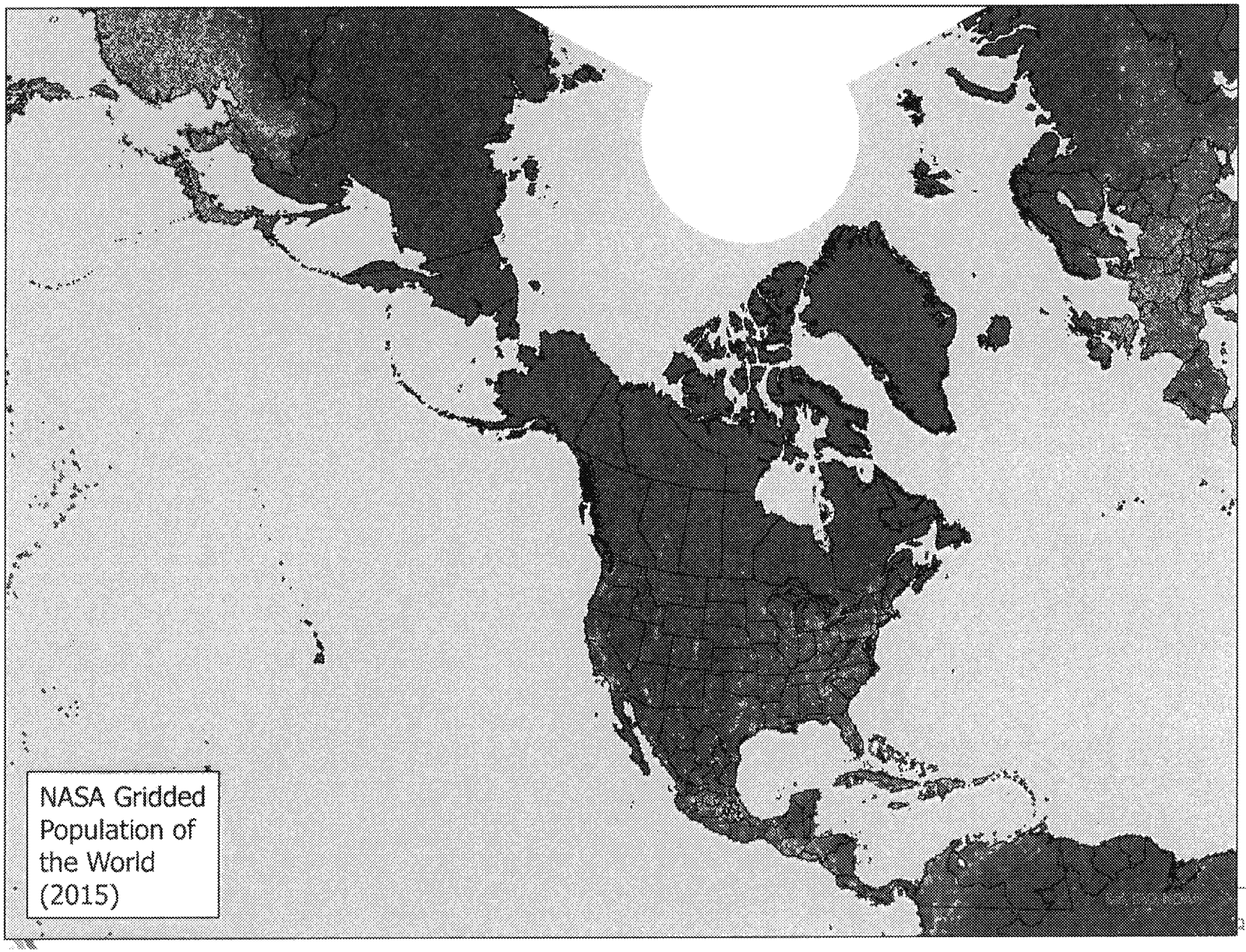






- No significant difference in transport patterns between exceedance and non-exceedance days.
- While the fraction of particles over Canada increased during exceedance days compared to non-exceedance days, this fraction is smaller than that over the US. Also, using "population count" (see next slide) as a proxy for urban emissions, significant emission contributions from outside the US are not expected.

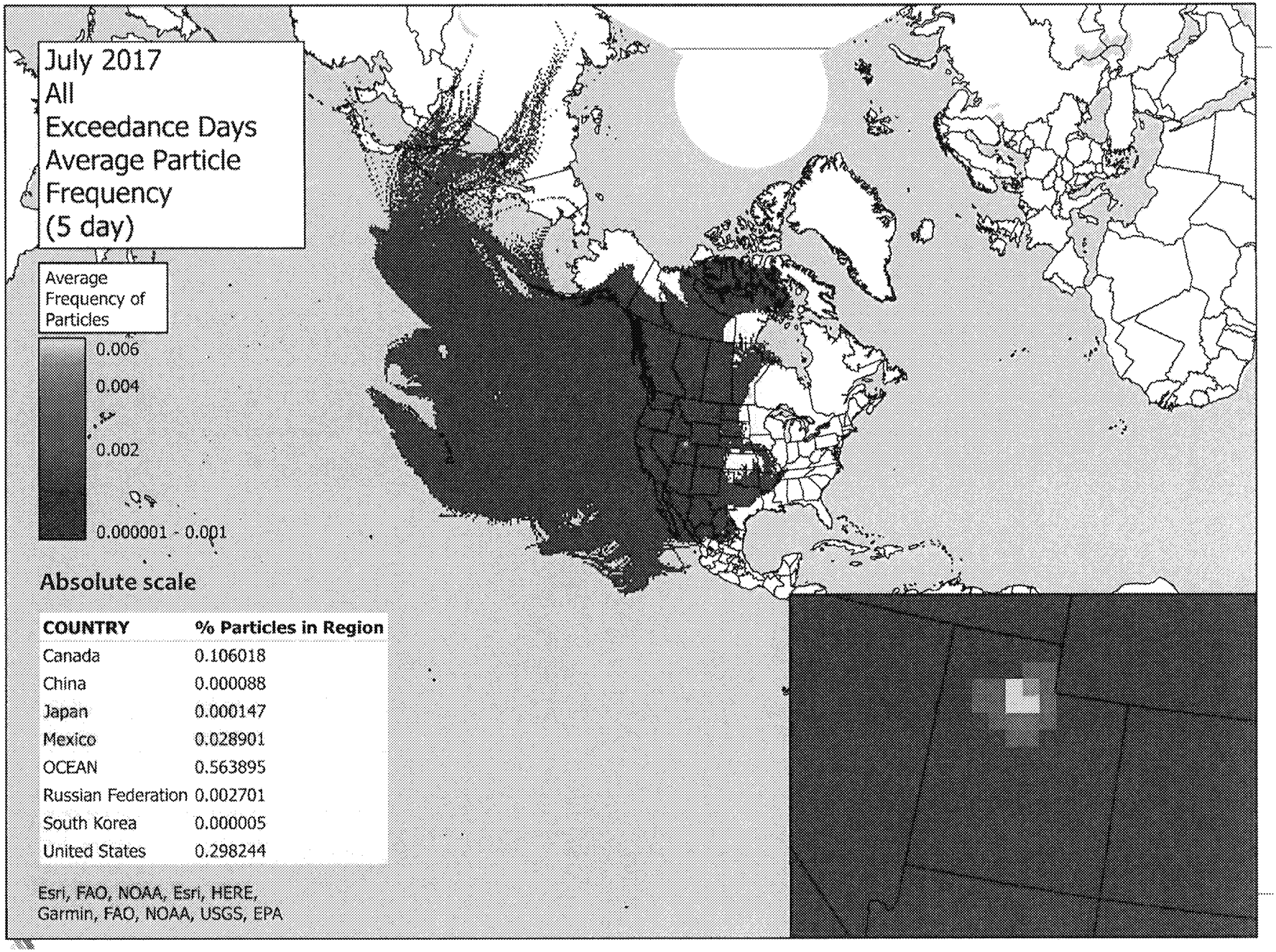
Gridded World Population (NASA) 2015

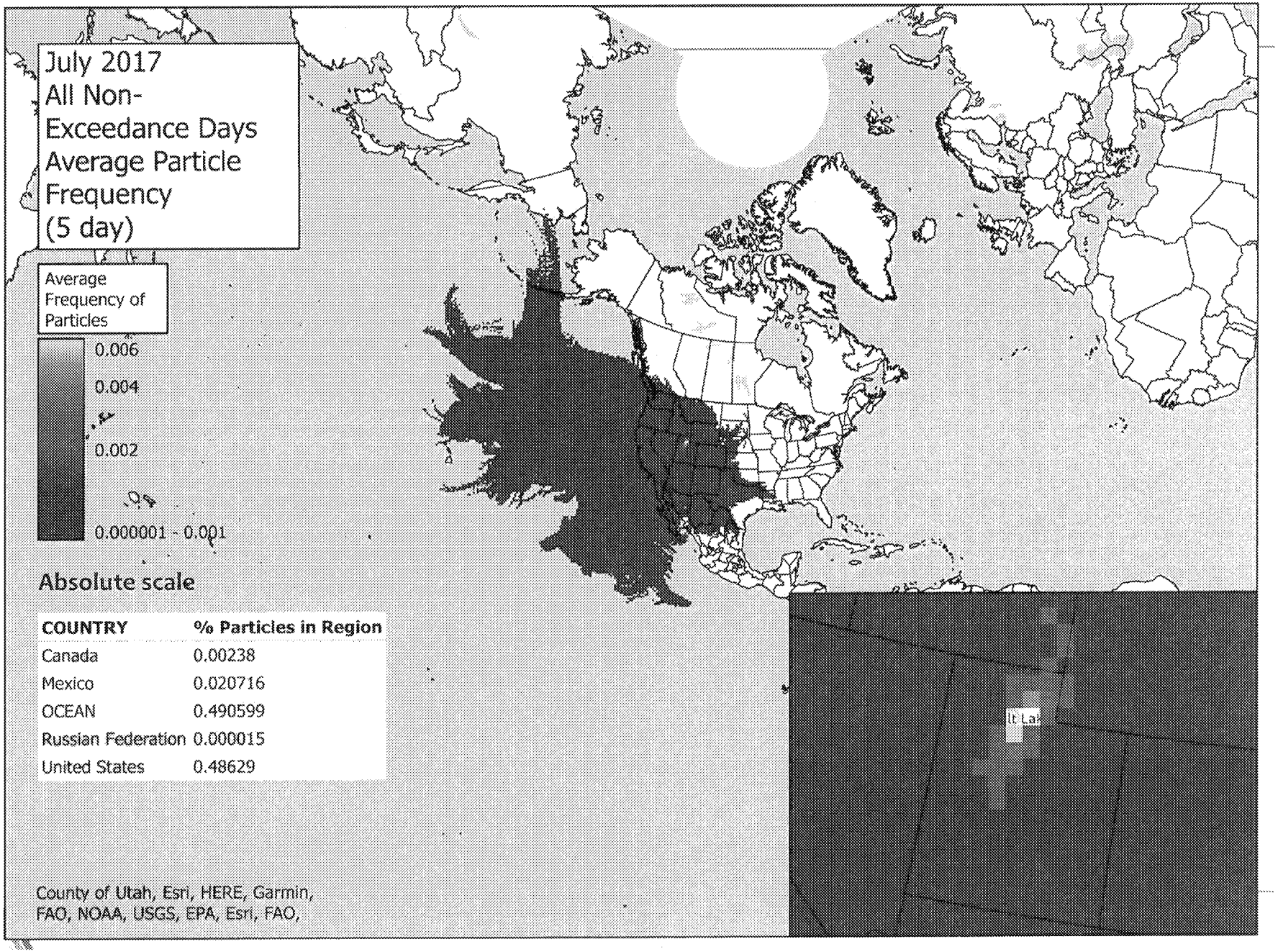


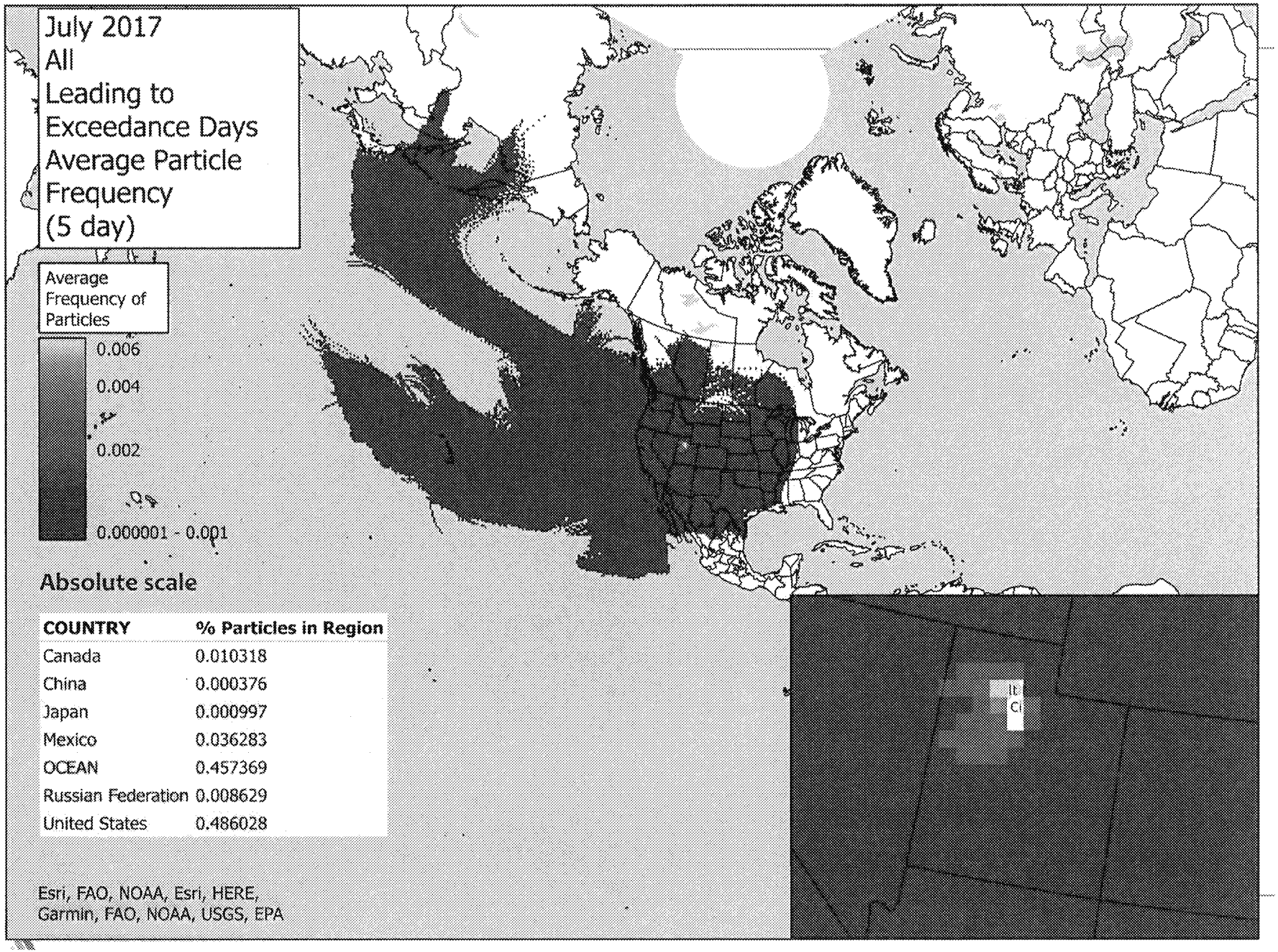
Key Findings

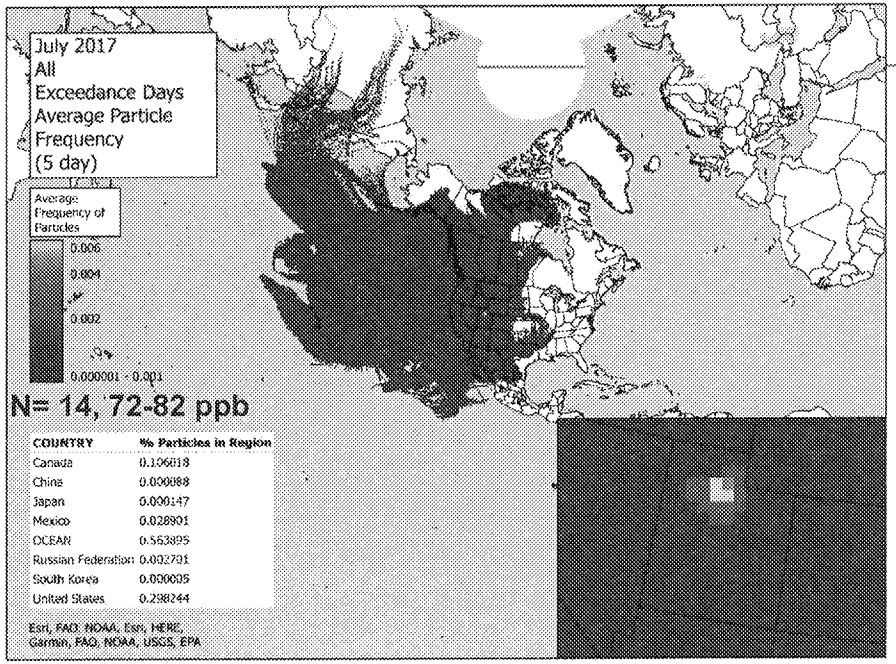
- Overall consistent findings between the synoptic patterns and HYSPLIT backward dispersion analyses
- Results do not suggest a strong impact from international emission sources on local ozone concentrations:
  - Peak ozone measurements do not coincide with frontal passage, which would be expected with long range transport of international emissions.
  - No significant difference in transport patterns between exceedance and non-exceedance days
  - Increased particle count over the US compared to other urban regions

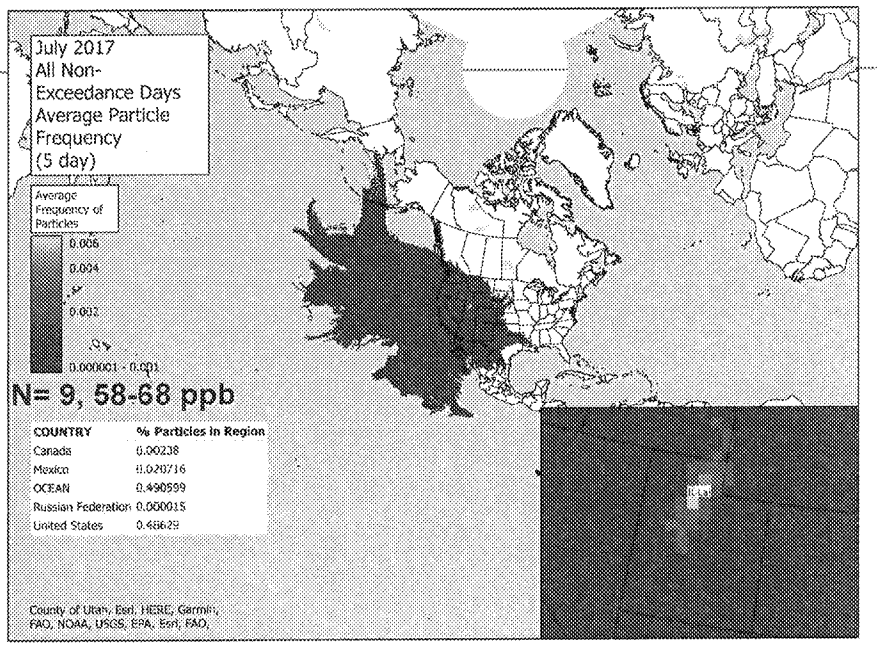
Supplementary Slides

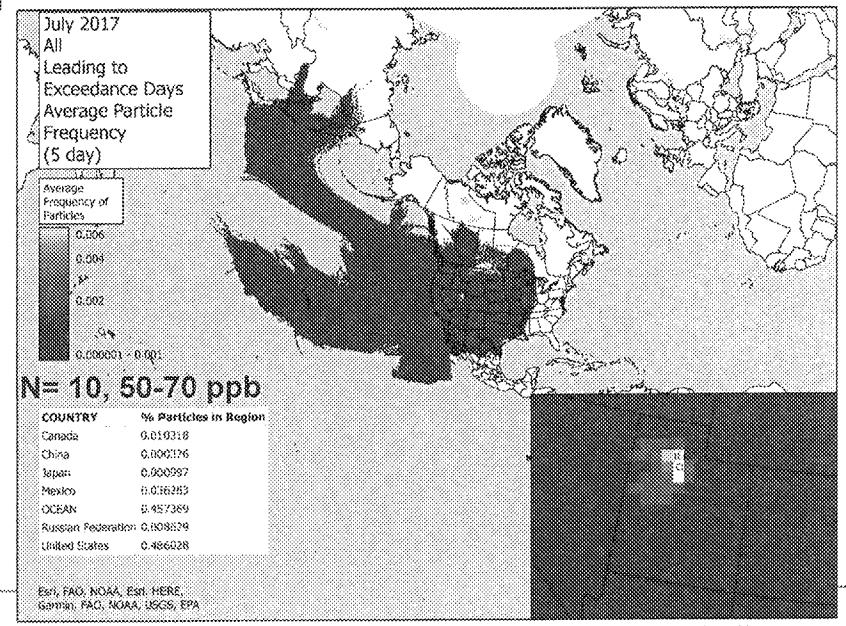

July 2017
All
Exceedance Days
Average Particle
Frequency
(5 day)
Average
Frequency of
Particles
0.006
0.004
0.002
0.000001 - 0.001
Absolute scale
COUNTRY % Particles in Region
Canada 0.106018
China 0.000088
Japan 0.000147
Mexico 0.028901
OCEAN 0.563895
Russian Federation 0.002701
South Korea 0.000005
United States 0.298244
Esri, FAO, NOAA, Esri, HERE,
Garmin, FAO, NOAA, USGS, EPA


July 2017
All Non-Exceedance Days
Average Particle Frequency
(5 day)
Average Frequency of Particles
0.006
0.004
0.002
0.000001 - 0.001
Absolute scale
COUNTRY % Particles in Region
Canada 0.00238
Mexico 0.020716
OCEAN 0.490599
Russian Federation 0.000015
United States 0.48629
County of Utah, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, FAO,


July 2017
All
Leading to
Exceedance Days
Average Particle
Frequency
(5 day)
Average
Frequency of
Particles
0.006
0.004
0.002
0.000001 - 0.001
Absolute scale
COUNTRY % Particles in Region
Canada 0.010318
China 0.000376
Japan 0.000997
Mexico 0.036283
OCEAN 0.457369
Russian Federation 0.008629
United States 0.486028
Esri, FAO, NOAA, Esri, HERE,
Garmin, FAO, NOAA, USGS, EPA





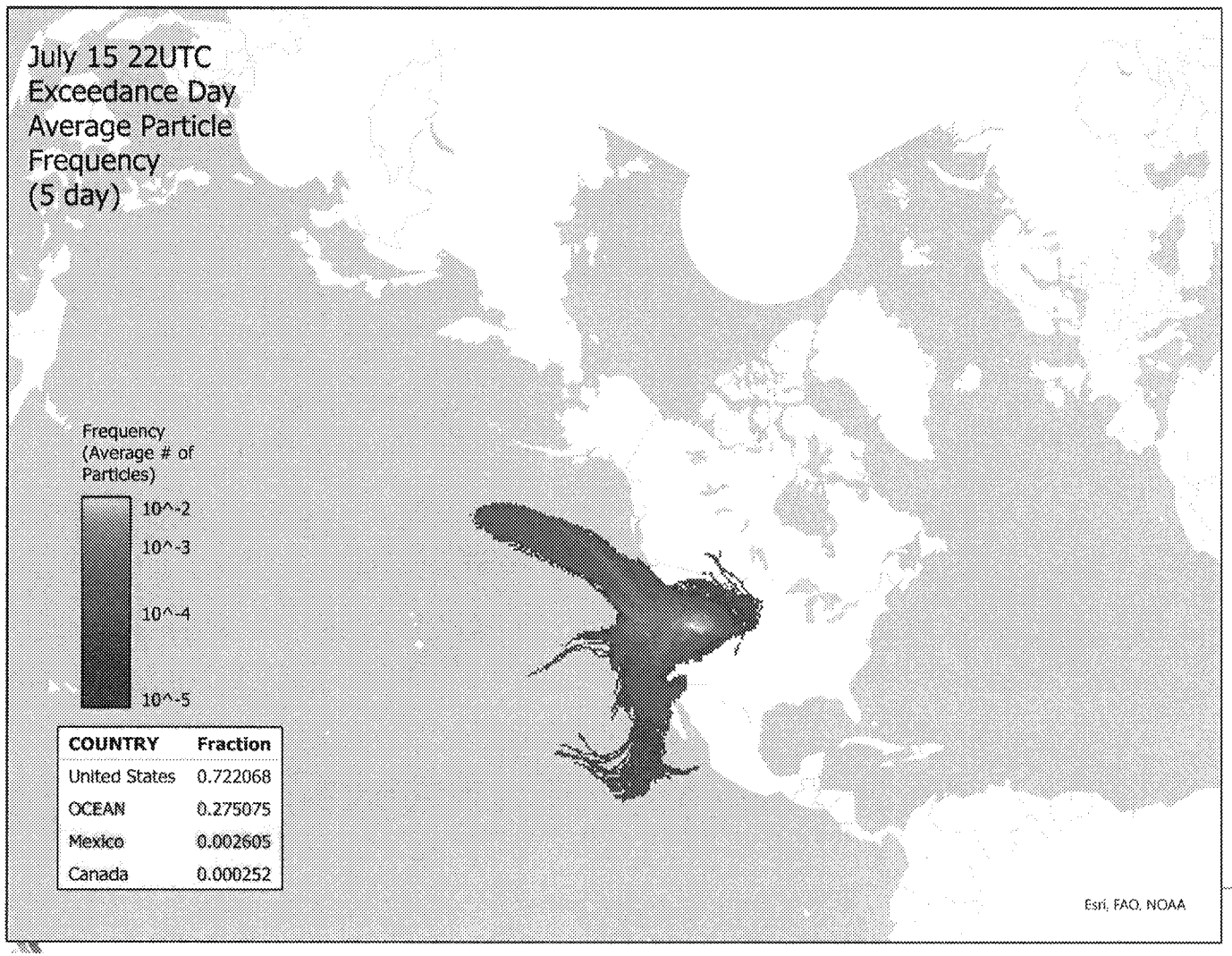


Absolute scale

- No significant difference in transport patterns between exceedance and non-exceedance days.
- While the fraction of particles over Canada increased during exceedance days compared to non-exceedance days, this fraction is smaller than that over the US. Also, using "population count" as a proxy for urban emissions, significant emission contributions from outside the US are not expected.

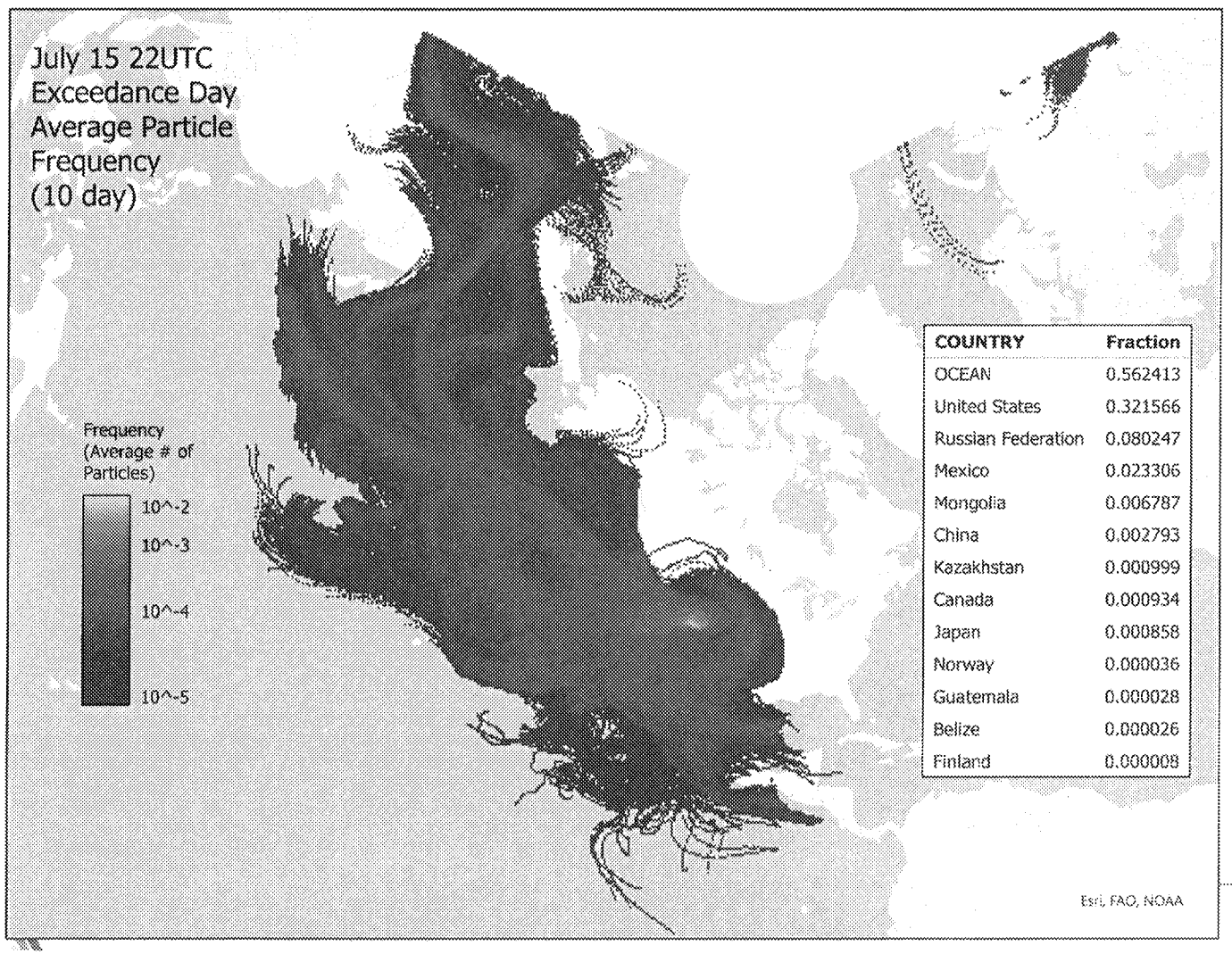
Exceedance (5day backcast, large domain)

July 15 Average Particle Frequency



Exceedance (Extended 10 day backcast)

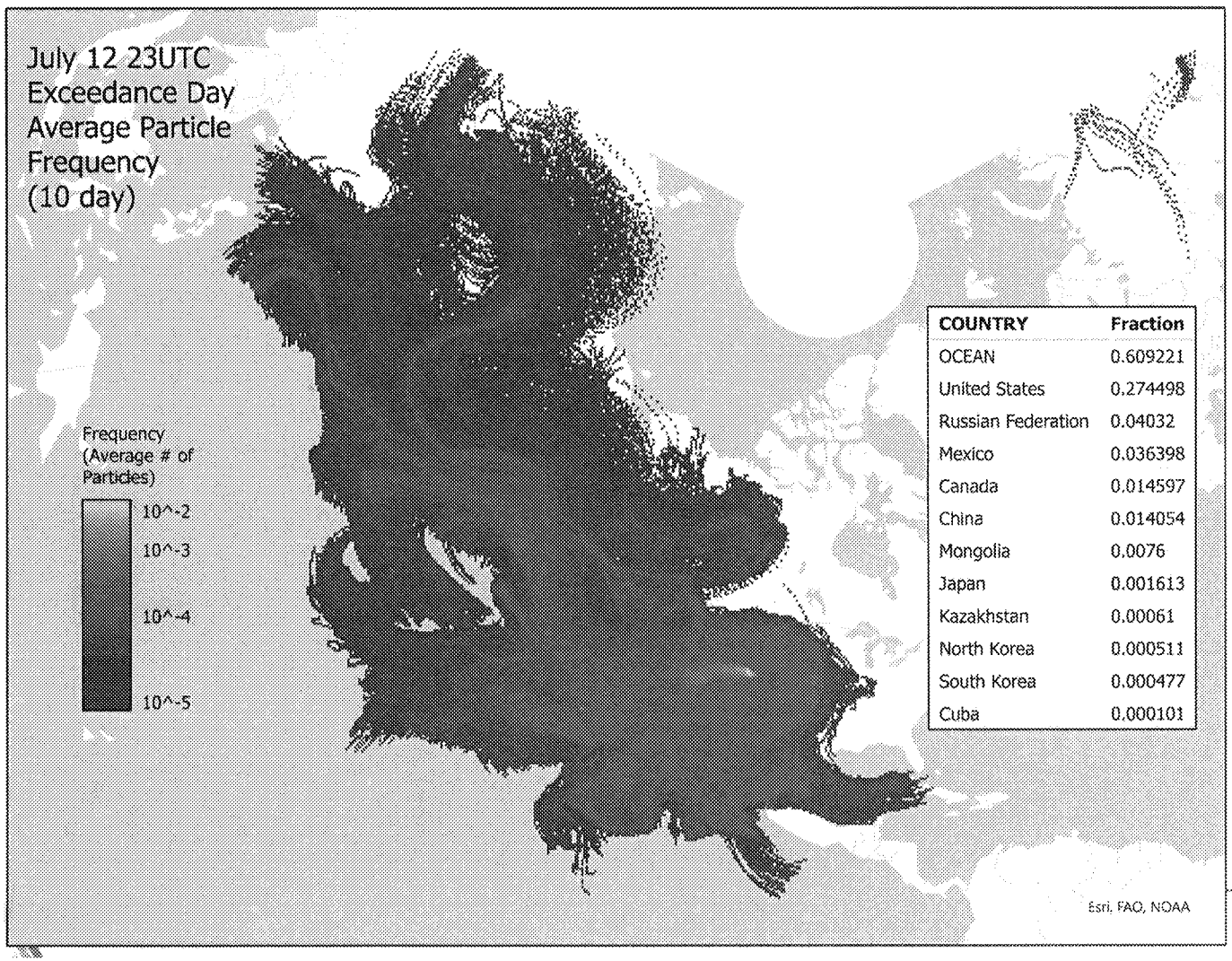
July 15 Average Particle Frequency



COUNTRY	Fraction
OCEAN	0.562413
United States	0.321566
Russian Federation	0.080247
Mexico	0.023306
Mongolia	0.006787
China	0.002793
Kazakhstan	0.000999
Canada	0.000934
Japan	0.000858
Norway	0.000036
Guatemala	0.000028
Belize	0.000026
Finland	0.000008

Exceedance (Extended 10 day backcast)

July 12 Average Particle Frequency



COUNTRY	Fraction
OCEAN	0.609221
United States	0.274498
Russian Federation	0.04032
Mexico	0.036398
Canada	0.014597
China	0.014054
Mongolia	0.0076
Japan	0.001613
Kazakhstan	0.00061
North Korea	0.000511
South Korea	0.000477
Cuba	0.000101

Division of Air Quality